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THE APPLICATIONS OF ELECTRICITY TO THE DEVELOPMENT OF MARKSMANSHIP.

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[*A Lecture delivered before the* FRANKLIN INSTITUTE, *March 15, 1886.*]
(*Concluded from July issue.*)

I have dwelt somewhat at length upon the development of the method of measuring initial velocity, not only to show the absorbing interest taken in this problem by scientists, not only to show the foundations upon which later modern practice is built, but mainly to show that in all these investigations *powder* was the chief subject. In the "Artillerists's Manual," written in 1859, General John Gibbon, another Philadelphian, by the way, first asserts that the Robins method "appears to have had its day, and to be obliged to give place to one destined, it is thought, to supersede it entirely, and of such accuracy and minuteness in its results as seem to preclude the idea of any further improvements in the measurement of the flight of projectiles. "It is evident," he continues, "that if any machine can be produced for measuring the

flight of projectiles, and can be indiscriminately applied to every gun used as it is in actual service, and be made to exhibit accurately the time occupied by the ball in passing over different parts of the trajectory, the whole problem of measuring the force of gunpowder is solved. * * * Such an instrument has been invented in the electro-ballistic apparatus of Captain Navez, of the Belgian army; and one cannot read the accounts of its wonderful operations without being struck with astonishment that such an instrument should have been invented ten or twelve years ago. * * * without finding its way into this country. * * *." This well illustrates that a prophet may long be without honor in his own country; for, over sixteen years before this was written, a

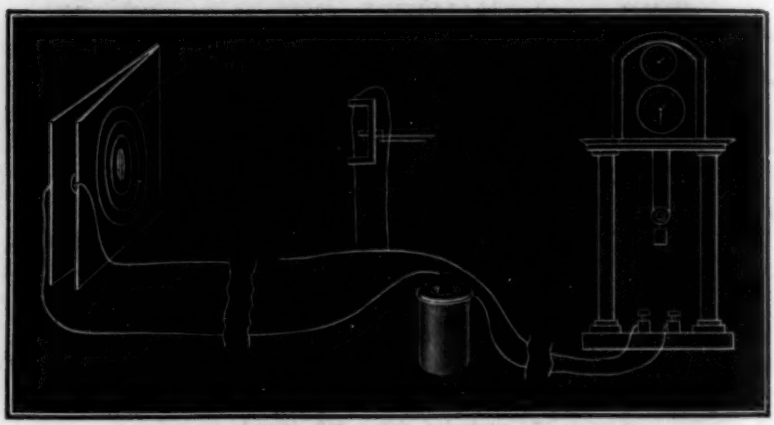

FIG. 8.—Wheatstone's Chronoscope. (Installed.)

great American *savant* published here, in your city, a full description of an instrument that fulfilled all the conditions so well stated by General Gibbon. And now, after "this intolerable deal of sack," I come to the "one half-pennyworth of bread"—the application of electricity to the measurement of initial velocities. Who first suggested this application? Most writers appear to agree that the honor belongs to Wheatstone, and assign 1840 as the date; still, Germany claims it for Siemens; Russia and France for Konstantinoff and Breguet, a scientific copartnership; and Belgium for Navez.

But we have strong ground for considering our own revered Henry as the deviser of the first complete electro-ballistic chronograph, or instrument for recording by electrical agency the time

occupied by a bullet in its passage between two points, a given distance apart. I will briefly tell you what was proposed in Europe and America, and let you decide the question of priority of invention. Professor Charles Wheatstone first measured the velocity of electricity in 1834, using for the purpose a timed revolving mirror. In continuation of these experiments with the intention of observing and registering minute intervals of time, he undoubtedly projected a "chronoscope," operated by the automatic agency of electro-magnets. He had in view the determination of the time of falling bodies, the observation of the duration of gunpowder explosions, and other delicate investigations. This ingenious device was adapted for the measurement of initial velo-

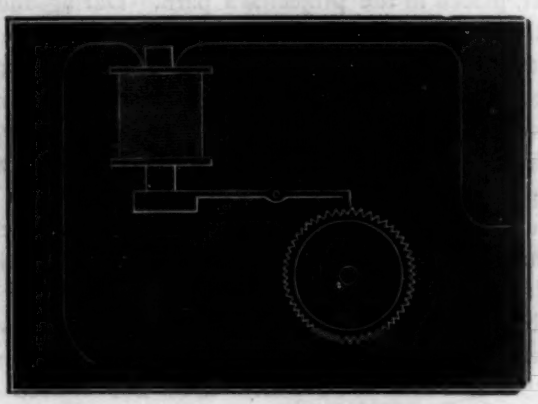

FIG. 9.—Electric Pawl, as applied in Wheatstone's Clock.

cities, but the precise time at which this novel application was suggested, it is difficult to determine. He first *published* an account of this application, induced by circumstances which I will mention directly, in 1845. We know, however, that in 1842, Colonel Konstantinoff, an able Russian artillery officer, visited England, and while there, Wheatstone showed and explained his original chronoscope to him, with inferable consequences that you will see presently. Virtually Wheatstone used a clock, whose train was released by the falling out of gear of the armature of an electro-magnet consequent upon the rupture of a galvanic circuit, and again arrested by the throwing into gear of the same armature upon the re-establishment of the circuit.

You can readily see that the inertia of the train, variations in

residual magnetism, and time required for re-establishing the circuit were sources of error. In the published "Proceedings of the American Philosophical Society of May 30, 1843," is an abstract of Professor Henry's paper, "On a New Method of Determining the Velocity of Projectiles." He used a revolving cylinder, Mattei's apparatus revived, actuated by a clock train so as to make ten turns per second, the surface was divided into 100 equal parts, each part therefore corresponding to the $\frac{1}{1000}$ of a second. Two galvanometers were established close to the cylinder, at opposite ends of a diameter, whose needles were furnished at one end with a pin for making dots on the cylinder. Each galvanometer was in a circuit passing respectively through two screens, a known distance apart, placed in the projectile's path. During the continuance of the currents, the galvanometer needles were deflected against a steady pin, but upon their rupture, the marking ends of the needles were thrown against the cylinder by fine spiral springs coiled about the centre pins of the needles, and thus "dotting" the cylinder. Of course, the position of the dots gave the time of the ball's passage between the screens. I cannot help admiring the completeness of detail of Henry's chronograph, for he provided against almost every instrumental error. His "steady pins" were movable, by which the excursion of the needles could be increased or diminished, and his spiral springs were governed just as are those of our watches. He recognized fully the necessity of the needles describing their small arcs, which need not exceed the one-twentieth of an inch, in equal times. To insure this he brought his two circuits together by a common wire, which dipped into a cup of mercury; this he lifted out while the cylinder was rotating, and adjusted the needles, until the dots were exactly at opposite ends of the diameter. In order that the pins might not obliterate the dots in describing their circles, Henry recommends that the cylinder be also given a slow translating motion. In a subsequent communication to the Recorder, Prof. Henry proposed to substitute induction coils for the galvanometers, whose sparks, upon rupture of the primary circuits, would perforate the graduated paper covering of the cylinder, and added: "In the same way the terminal points of wires from a number of different pairs of screens may be made to impress their marks on the surface of the same cylinder, and the velocity of the ball at

the different points of its path may in this way be determined by a single experiment." Prof. Henry was undoubtedly the first to suggest the application of the induction coil, thus eliminating the errors due to remaining magnetism, and he was the first to suggest an apparatus capable of recording continuing observations on one trajectory. Colonel Konstantinoff, evidently impressed with the feasibility of applying Wheatstone's device to military purposes, at once gave his attention to its modification, and in conjunction with the ingenious Breguet, began at Paris, in June, 1843, the construction of an apparatus that should record many time observations within a single trajectory. This was completed in May, 1844, and it was described before the French Academy, January 20, 1845. In this instrument the records were made upon a revolving cylinder,

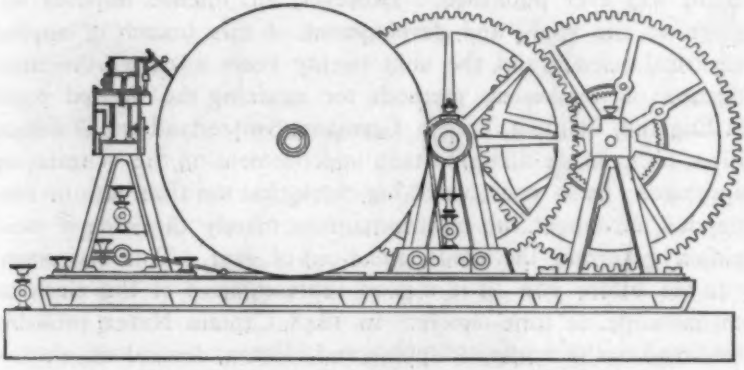

FIG. 10.—Konstantinoff-Breguet Chronoscope.

timed by a Breguet recorder, by styles operated by electro-magnets at the moment of successive ruptures of the circuits. Wheatstone's remonstrance, together with a description of his own apparatus, was presented to the Academy, four months later, May 26, 1845. Konstantinoff's device of 1844, resembled much more closely Henry's, described and published in 1843, than Wheatstone's, described and published in 1845.

The main difference between the Henry and the Paris apparatus lay in the substitution of electro-magnets for galvanometers.

Certainly Henry's suggested use of the secondary current was far more delicate than either, as it avoided the inertia of the needle or the armature, and is the exact method now followed in our most delicate instruments. It seems strange that with the very best

form of electro-ballistic chronograph first described by one of our own people, we have permitted others to carry off all the honor of practically originating, applying and developing, to such an extent indeed, that with one exception—General Benêt's "Electro-ballistic Machines"—Henry's name is not even mentioned by the authorities. Very likely the Mexican war, the discovery of gold in California, Indian hostilities, and the slavery discussion, combined to prevent the evolution of an earlier Edison, who would have made the world ring with the merits of the invention.*

Captain Navez, of Belgium, claims to have had, in 1841, the idea of suspending the moving screen of Colonel Dobooz, already described, by an electro-magnet, but if experiments were made, they amounted to nothing, and certainly no account was ever published. However, an intense impetus was given to the study and development of this branch of applied electrical science, and the next twenty years witnessed the introduction of numberless methods for attaining the desired result in England, Belgium, France, Germany, Switzerland and America. First, Hipp made an important improvement in the Wheatstone apparatus; he so constructed his clock that the train was in continuous movement, the electro-magnets merely throwing a small pinion governing the hands in and out of gear. This instrument you see before you—it is a good representative of the electrical chronoscope, or time-*shower*. In 1848, Captain Navez, probably well-read in the works of Robins and Hutton, devised an electro-ballistic pendulum, which appears soon to have been considered as the best, and most practical means for determining initial velocities. Changed and improved, it became in 1858, the standard velocimeter in all military countries, and is the instrument so highly eulogized by General Gibbon. It maintained its supremacy well into the sixties, but is now relegated to museums, from one of which I have exhumed the specimen before you. We have just seen that the swing of a pendulum is a simple and constant time measure at any assumed place. Now, suppose we could start a pendulum swinging at the precise instant when a projectile passed a given point, and stop it again at the precise instant when the

* After the lecture, Major Mordecai informed me that he distinctly recalled Prof. Henry's visiting Washington Arsenal, while the pendulums were erecting, and telling him that the velocity could be determined by electricity.

projectile passed another given point, then knowing the extent of the swing, we would know the time occupied by the ball in passing between the two points, and consequently its velocity, which is the distance divided by the time. This is just what Captain Navez did. He suspended a pendulum by means of an electro-magnet in circuit with one target. The bullet breaks this and the pendulum falls. On the breaking of a second target, the pendulum is stopped by means of another electro-magnet, then thrown into circuit. The pendulum swings in front of a graduated arc, and as it would require a large magnet, and induce severe strains, to attempt to stop it suddenly, a light index needle swings by friction with it, and this is arrested at the proper moment, while the pendulum is free to continue its movement. This would be very simple if the bullet

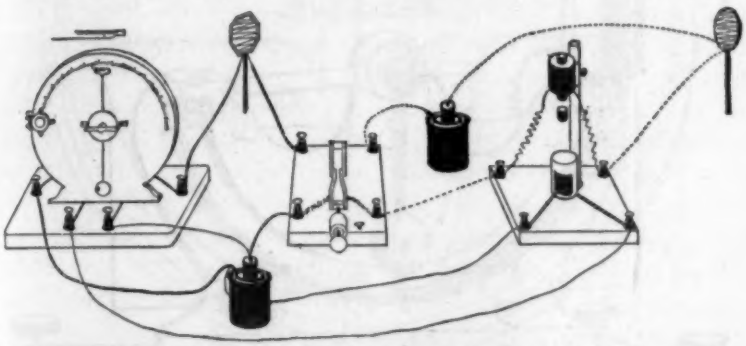

FIG. 11.—Navez's Electro-Ballistic Pendulum, installed with Conjunctor and Disjunctor.

completed a circuit in passing the second target, but it breaks one, and so a rather complicated piece of mechanism, called a conjunctor, also furnished with an electro-magnet, had to be introduced in order to establish the index-needle stopping current, when the bullet broke the target current. We would use an ordinary telegraph relay for this purpose. Now, the electro-magnets and the conjunctor require time for their operation, small in itself but large in proportion to the whole time to be observed, and this instrumental time has nothing whatever to do with the duration of the bullet's flight between the two targets. But it is included in the total recorded swing of the pendulum; we must therefore find out what it amounts to in swing and deduct it in each case from the whole observed oscillation. This is done by means of a disjunctor, an instrument that cuts the circuits of both targets simultaneously.

The swing recorded under these circumstances corresponds to the instrumental time.

Henry's idea of utilizing the induction spark for recording, for which no credit has been given him by European writers, was applied about 1857, by Captain Martin de Brettes, and at about the same time by Captain Vignotti, both of the French army. The latter's instrument is before you; it is Navez's pendulum combined with Henry's spark. Here the pendulum is sustained by an electro-magnet whose circuit is ruptured by the ball on leaving the muzzle. The pendulum, which is in the secondary circuit of two Ruhmkorff coils connected in series, begins falling,

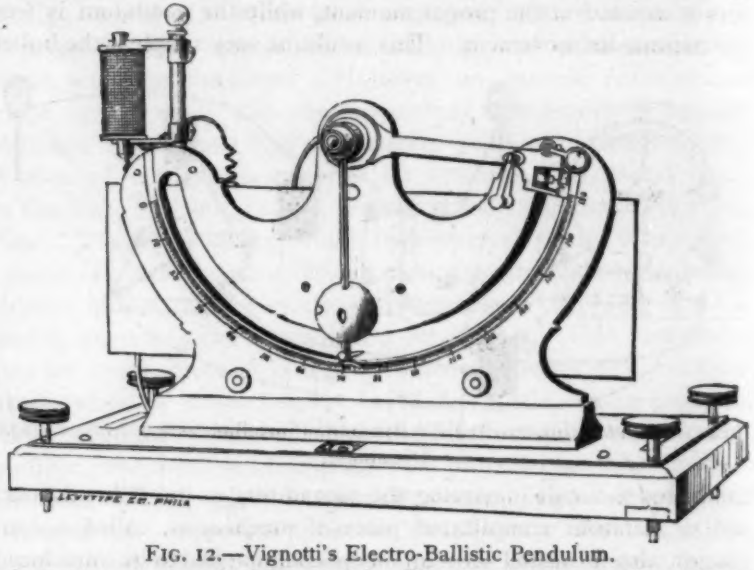

FIG. 12.—Vignotti's Electro-Ballistic Pendulum.

the exact moment is immaterial. The targets are in the primary circuits of the coils; their rupture causes sparks to pass from the pointer on the pendulum to the metal plate at the back of the slotted arc; upon this plate is stretched a paper strip dipped in potassium ferro-cyanide, so that the location of the sparks may be evident. The swing between the sparks, as in the Navez, corresponds to the time of the ball. Here we need take no account of the instrumental time, for the determining records are not made until after the pendulum has begun its oscillations.*

* This instrument was greatly improved at the Frankford Arsenal by Colonel Laidley, U. S. A., and Mr. Henry Wernle, the mechanician of the Ordnance Department.

In 1859, Colonel Benton, of our army, to whom, more than any other, is due the development of the present Springfield rifle, designed his electro-ballistic pendulum, a modification and simplification of the Navez machine. Benton used two equal concentric pendulums, suspended by electro-magnets with their "bobs" opposite to each other.

The ruptures of the targets liberated the pendulums successively, and in passing each other the point of meeting was

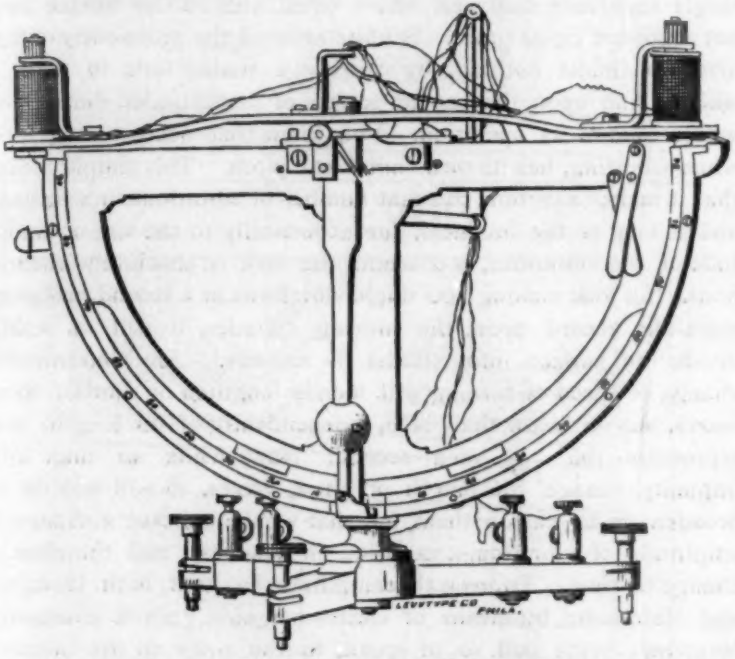

FIG. 13.—Benton's Electro-Ballistic Pendulum.

noted on the graduated arc, without interference with the swings. The time sought is the difference between the swings. A disjunctor was required to determine the instrumental time.

This instrument was in general use in this country until about 1874–75. About the close of the war, our Government, upon the recommendation of Colonel Laidley, had fabricated, by Froment, of Paris, a number of Schultz chronoscopes, apparently the limit of continuous electro-micro-chronometry. Captain Schultz, of the French Army, combining Wertheim's method of graphically

recording the vibrations of a tuning fork, Lissajou's and Helmholtz's way of making these vibrations electrically isochronous, and Henry's doubly-moving cylinder and induction spark, produced an apparatus that is capable of meeting every demand of interior and exterior ballistics.

In all previous applications of the cylinder for minute time recording, it was assumed that at least each single complete revolution was made uniformly. This is not true; the rate of even a single turn may vary, and hence equal arcs on the surface may not represent equal times. Schultz reduced the probability of this error to almost nothing, by causing a tuning fork to mark a sinuous line upon the sooted surface of his cylinder during the whole time of its operation. You know that every tuning fork, when vibrating, has its own individual pitch. This simply means that it makes a certain, constant number of vibrations in a second; and as long as the loudness, due acoustically to the size or amplitude of the vibrations, is constant, the fork is absolutely isochronous. If a fork making 500 single vibrations in a second makes its wave-like record upon the moving cylinder, it will in reality divide its surface into 500ths of seconds. Any intermittent change of speed of turning will merely lengthen or shorten these waves, but we know that each, independently of its length, still represents the $\frac{1}{500}$ of a second. Now, while we may with impunity change the length of these waves, it will not do to broaden or to narrow them, for that would indicate a change of amplitude of vibration, a variation in loudness, and therefore a change of time. To keep this amplitude constant, both Lissajous and Helmholtz, by means of electro-magnets, gave a constantly recurring, quick pull, so to speak, to the tines at the moment when they were nearest together, and thus increased the tendency to spread. Schultz uses this method for the same purpose. His interrupter, or device for imparting the electrical "pull" to the tines at the right moment, is a vibrating bar, dipping in and out of a cup of mercury, and requires skill and patience for its proper and continued adjustment. Captain Russell, of the Ordnance Corps, I suppose on the sound republican principle of making "every tub stand on its own bottom," made the tuning fork do its own interrupting, a plan you saw in operation at the Exhibition in the Delaney multiplex and other apparatus. This improvement

greatly facilitated the use of the chronoscope in determining initial velocities. You see now how a very correct time scale may be recorded upon the moving cylinder. Of what avail is this in ascertaining the time of flight of a projectile between two targets?

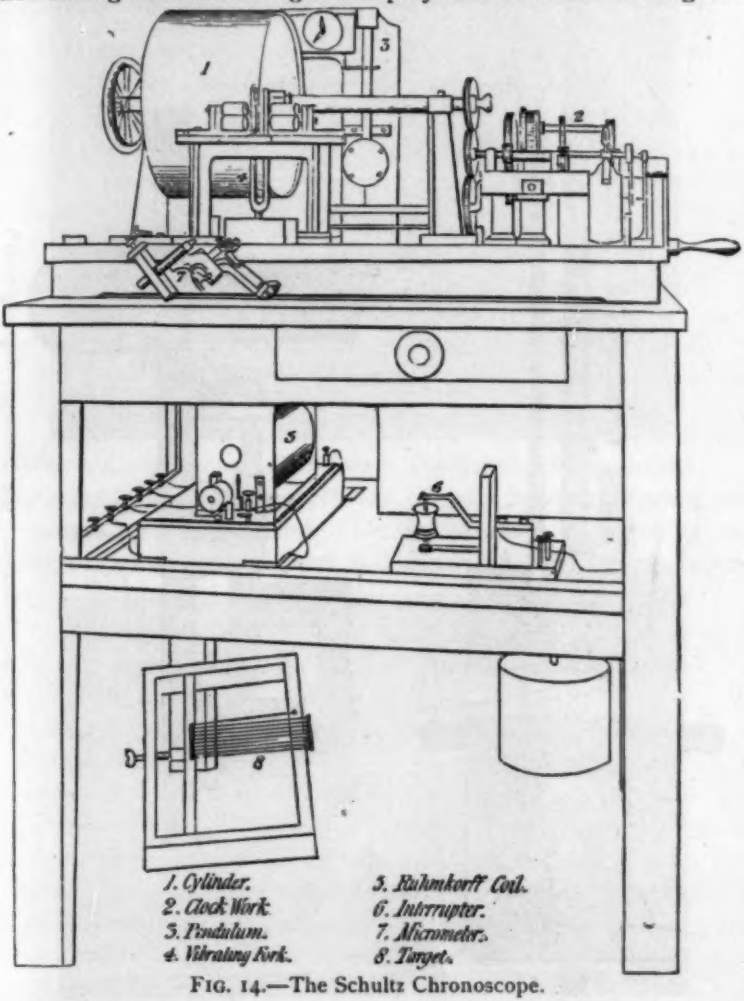

FIG. 14.—The Schultz Chronoscope.

Imagine the primary circuit of a Ruhmkorff coil to pass through the first target, having for one terminal of its secondary or induced circuit the metallic cylinder, and for the other an insulated point close to its soot-covered surface, and alongside the tuning fork tine that traces the waves.

It is evident that as the bullet ruptures the first target, a spark will pass from point to cylinder, and, burning away the soot, leave

FIG. 15.—The Le Boulengé Chronograph.

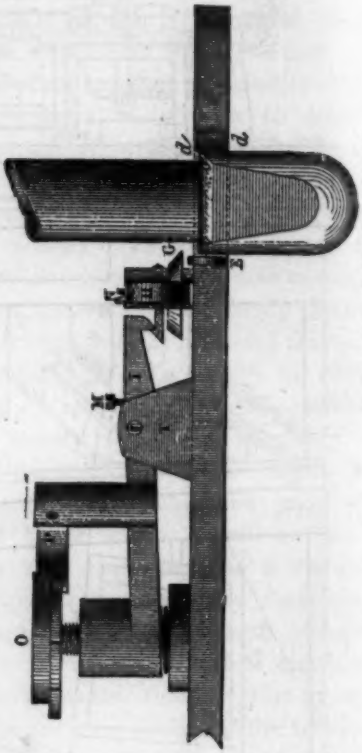

FIG. 16.—Indenter. (Le Boulengé Chronograph.)

exposed the silvered surface below. This, of course, marks the moment of the bullet's passing the first target. If before it

arrives at the second target the primary circuit be re-established, a second spark will again record on the moving cylinder the moment of the bullet's passage. To do this, Schultz made a first target

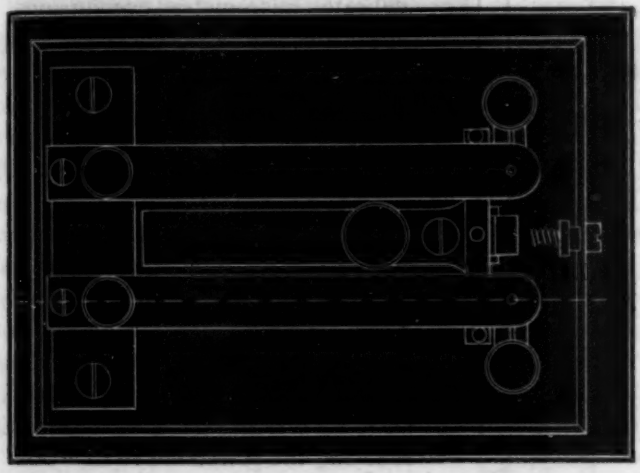

FIG. 17a.—Disjunctor. (Top View.) (Le Boulengé Chronograph.)

very much like a gridiron, each bar or wire bending a spring out of contact with a metal stop. On the breaking of a wire by the bullet, the spring was released, and, in touching the stop, re-estab-

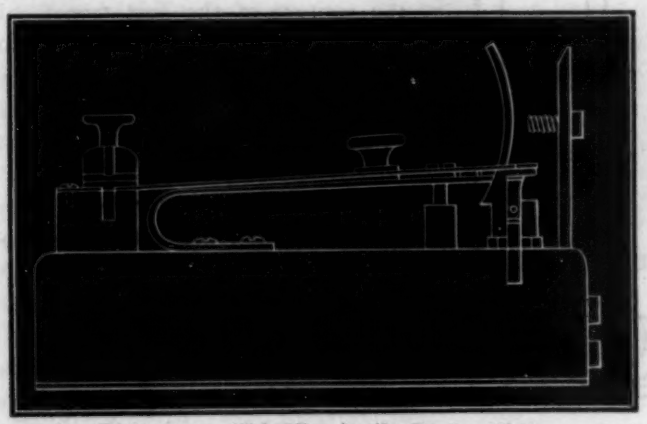

FIG. 17b.—Disjunctor. (Side View.) (Le Boulengé Chronograph.)

lished the primary circuit. With our tendency to get rid of the cumbersome, we threw this aside and substituted the ordinary telegraph relay and other simple devices. Nothing remains but to

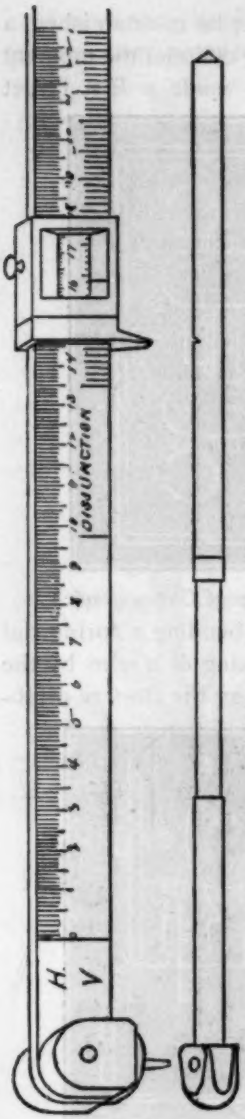

FIG. 18.—Velocity Scale. (Le Boulengé Chronograph.)

count the number of waves and fractions between the two sparks and we have the time and consequently the velocity. A delicate micrometer accompanied the apparatus, by which a wave may be divided into 1,000 parts, each division corresponding to the $\frac{1}{500,000}$ of a second.

In 1863, Colonel Le Boulengé, of the Belgian Army, a most talented officer, devised his chronograph, which, toward 1870, on account of its accuracy, simplicity, portability and cheapness, was adopted in all countries. A falling body is a good time-piece, but it must not be interfered with. In the pendulum, the friction of the axis is a disturbing influence. Le Boulengé got rid of this by reducing the pendulum to its "bob" and allowing it to fall without any restraint whatever, until *after* the record had been made. He suspended a long rod by an electro-magnet, which begins falling upon the rupture of the first target. Upon the rupture of the second target another rod, also suspended by an electro-magnet, drops upon a lever, thereby releasing a spring knife, which, in jutting forward, dents the first rod in its fall. The position of the dent on the rod gives the amount of fall, hence the time, and, as before, the velocity. As with the Navez and Benton machines, an ingenious disjunctor determines the instrumental time. The great practical merit of the instrument lies in the fact that this instrumental time can be made *constant*, which permits us to measure off the *velocity* directly from the rod.

This is done as follows: Assume 100 feet between the targets an instrumental error of 0·15 seconds, and an initial velocity of

1,200 feet. Divide the space, 100 feet, by the velocity, 1,200 feet, and we have the time, ·08⅓ second, of passage between the targets; to this add the 0·15 second instrumental time, and we have ·23⅓ second for the time of fall of the rod, corresponding to a distance of ten and one-half inches. Therefore, in our measure, where usually we engrave ten and one-half inches, we would here put 1,200 feet. Of course, it is easy to extend this throughout the whole length of fall. Any one of ordinary intelligence and gentle touch can easily be taught to manipulate the instrument.

And now, in conclusion, I will show you the latest American invention in this department of applied science, a contribution to the Electrical Exhibition, the Cushing velocimeter. We have here the simplest and most constant of all minute time-dividers, an electrically controlled tuning fork, and the Morse recording ribbon sensitized for the galvanic current. Mr. Cushing certainly deserves great credit for thus ingeniously combining two well-known and easily controlled devices, and producing an apparatus, which, while not yet sufficiently accurate for profound scientific research, offers a simple, economical, and correct method for ordinary testing.

In operating the instrument, the paper strip is reeled off by hand; upon it rest three fine iron wires, through the centre one passes the vibratory current, (not Keeley's) that controls the fork, or rather reed, for the fork is reduced to one tine, through the other two, the respective target currents. The centre wire records a continuous dotted line corresponding to the reed's vibrations, the other wires trace straight lines. Upon the rupture of the currents at the targets, these lines are broken. The number of vibrations and fractions recorded between the breaks gives the time. You see that the Cushing velocimeter is the Schultz chronoscope in "shirt sleeves."

To recapitulate, the electric instruments for measuring initial velocities devised up to the present time, may be classified as follows:

Chronoscopes, or direct time-showers.

REPRESENTATIVES.

Wheatstone, Hipp, de Brettes, and others.

Chronographs, or time-writers, subdivided according to the method of recording.

(1.) Upon a timed revolving cylinder—Henry, Konstantinoff, Breguet, Bashfort, Noble, (here the cylinder is divided into parallel discs.)

(2.) Upon a cylinder continuously rotated—Schultz, Cushing, (the cylinder is reduced to a moving strip.)

(3.) By a pendulum—Navez, de Brettes, Vignotti, Benton, Leurs.

(4.) By a freely falling body—Le Boulengé, Watkins.

(5.) By galvanometer deflections—Pouillet, Breguet.

I hope that in this lengthy, sometimes necessarily technical, paper, I have made one thing clear to you, that the application of electricity to the determination of initial velocity has reduced the cumbersome ballistic pendulum, an apparatus, to the simple chrono graph, a tool; that it has done away with all abstruse calculation, and has substituted therefor the method of the foot rule; that it has made it possible for every powder manufacturer to do his own proving. He can now ascertain the velocity of his powder as easily and surely as the apothecary weighs the ingredients of a prescription. He knows what is required—he can produce it, not once, but always. He can make a constant powder, and, as I endeavored to show you in the beginning, upon the uniformity of the powder depends the accuracy of the marksman.

DANGER OF ELECTRICITY FROM BELTS.—M. Boher, the inspector of lighting, in Dresden, has found that the belts even of ordinary steam engines often develop electricity enough to illuminate Geissler tubes and to perform all the ordinary experiments for which electrical machines are used. He thinks that many of the explosions in flouring mills may have been produced by such electricity.—*Cosmos, Sept. 28, 1885.*

APPARENT ENLARGEMENT OF THE SUN AND MOON WHEN NEAR THE HORIZON.—Paul Stroobant attributes the apparent enlargement of the heavenly bodies when near the horizon to the combined action of two causes: the first being an apparent reduction of an object in the zenith to about four-fifths of the dimensions of the same object when placed in the horizon; the second being the diminution of brilliancy when the body is rising or setting. The first of these causes appears from Stroobant's experiments to be independent both of the position of the observer's head, and of the apparent flattening of the celestial vault. The question, therefore, is not yet settled, but the observations upon stars at different heights and the experiments with an artificial disc dimly illuminated are ingenious and interesting.—*Bul. de l'Acad. de Belg., No. 8, 1885.*

EXPERIMENTS ON THE TRANSMISSION OF POWER BY GEARING.—MADE BY MESSRS. WILLIAM SELLERS & CO.*

By Wilfred Lewis, Philadelpha, Pa.

[*A Paper read before the American Society of Mechanical Engineers, at the Boston Meeting, 1885.*]

(*Concluded from vol. cxxi, 467.*)

DISCUSSION.

Mr. H. R. Towne.—The relative efficiency of worm and spur gearing has heretofore been largely a matter of speculation and theory, authorities differing widely in regard to it, and no reliable information being given in the text books as to the true efficiency of either under the conditions of ordinary practice. The experiments now under review go further to supply this deficiency than anything previously published, and are of corresponding interest and importance.

The practical value of all such information is increased by stating the results obtained in a summarized form, convenient for reference, and so far condensed as to admit of the whole being comprehended at one time, and with reference to the relationship of each of the several deductions to the others. Such a summary of the experiments presented by Mr. Lewis seems to afford the following deductions and indications:

(1.) That spur gearing is decidedly the most efficient mode of transmitting power by positive gears.

(2.) That the efficiency of a pair of good cut spur wheels, having a velocity ratio of one to three and one-third, ranges from eighty-six to ninety-nine per cent. under average conditions.†

(3.) That with spiral gearing the efficiency is increased with

* From Advance Sheets, Vol. VII, Transactions A. S. M. E.

† Referring to this deduction, Mr. Lewis comments as follows:

"Here I would prefer to see the velocity ratio eliminated, although I recognize it as a variable, which should, strictly speaking, be considered.

"The diagram (*Fig. 99*) is constructed without reference to anything but velocity at the pitch line of teeth, so as not to complicate the question more than is necessary for an approximate determination. As a result of this, I believe that the errors arising from neglecting the velocity ratio, size of

the angle of the thread until the spiral pinion becomes a spur pinion, when the axes of the pinion and its wheel become parallel.

(4.) That with worm gearing the efficiency corresponds at small angles (10° and less) very closely to that of spiral gearing. At greater angles the efficiency of worm gearing does not increase so rapidly as that of spiral gearing, and, unlike the latter, the possible angle of the thread is limited.*

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journals, etc., have a tendency to neutralize each other. For instance, supposing two cases of a wheel and pinion in each of which the same pinion is used. Let the wheel in one case be three times, and in the other six times the diameter of the pinion. For the same velocity of teeth, the pinion in each case makes the same number of revolutions, and the friction on its journals is the same. The smaller wheel, however, runs twice as fast as the larger, and there is consequently twice as much sliding in the journals in its case; but, on the other hand, the coefficient of friction for the smaller wheel is much less on account of higher velocity.

"By the same reasoning large journals would compensate partially, in the reduction of the coefficient of friction, for the increase in the amount of sliding. This feature is not proved, of course, but such a tendency, no doubt, exists, and is further augmented by the fact that, in general, the larger the wheel, the larger are its journals. It may be stated, as a general principle, that the higher the number of teeth gearing together and the smaller the journals, consistent with strength and stiffness, the greater the efficiency.

"The limits imposed upon all proportions of gearing by considerations other than that of efficiency do not, I think, admit of such great variations as to require in ordinary practice a consideration of the question of velocity ratio. Taking any pair of shafts connected by gearing, I think it will be admitted that the efficiency will increase with an increase in the size of either one of the gears, whether the velocity ratio becomes greater or less. I would suggest, therefore, that as the velocity ratio cannot be used as a guide or limit, it may properly be omitted from the statement covered by your second deduction from the experiments reported by me."

* On this latter point, Mr. Lewis suggests as follows:

"The limiting angle for the maximum efficiency of worm gearing is to be determined in a manner similar to that for screws, as fully explained in a paper which I prepared some years ago, and which may be found at page 73 of THE JOURNAL OF THE FRANKLIN INSTITUTE for February, 1880. The formula particularly referred to is No. 6, on page 76, from which it will be seen that the angle for greatest efficiency is probably limited to something approximating to 45°. Although this angle has been often used on screws with good results, I should hesitate to recommend it for worms on account of the heavy side thrust upon the worm wheel, and I am inclined to think that 30° is the more nearly correct figure for the limit for maximum efficiency of worms."

(5.) That the efficiency of spiral and worm gearing (of cast iron, machine-cut or worn smooth) ranges from thirty-five to ninety per cent., according to the conditions of speed, angle, pressure and quality of surfaces.

(6.) That with each kind of gears there exists a certain point of maximum efficiency, depending chiefly, under average conditions, upon the velocity of the rubbing surfaces.

(7.) That very high velocities develop a tendency of the rubbing surfaces to cut, and that this difficulty then becomes a limiting condition.

(8.) That with worm gearing, a large part of the applied power being lost in end-thrust on the worm shaft, it becomes correspondingly important to adopt a form of end-bearing which will diminish this loss as much as possible.

(9.) That the range of variation from the mean line of efficiency in the Sellers experiments rarely exceeds five per cent. in either direction, in the case of worm gearing, and is diminished to about three per cent. in the case of worms of high angles and spur gearing, so long as no cutting occurred, but that the variation became much greater and very irregular as soon as cutting began.

(10.) That in general, at slow speeds, the greatest efficiency is found under the heaviest pressures; at moderate speeds, under moderate pressures; and at high speeds, under light pressures. This seems to indicate a limiting point for the product of speed and pressure at which the heat of friction is so rapidly developed as to impair either the condition of the surfaces in contact, or their lubrication, and cause cutting.

(11.) That the liability to cutting depends upon the speed of sliding, being also affected by the quality of lubrication, the intensity of pressure, and the period of duration.

(12.) That with worms and spiral gears, time or duration of action is a limiting element, a good pair of gears being capable of efficient action for five or ten minutes, or more, but failure from cutting will result after the proper time is exceeded. (See table on page 453, vol. cxxi, J. F. I.)

(13.) That the maximum efficiency is attained at or below a velocity of 300 feet per minute of the sliding or rubbing surfaces, and that while it is possible to exceed this limit temporarily with good results, it is somewhat hazardous to do so. For continuous

work 200 feet per minute is probably the highest velocity of rubbing surfaces which can safely be adopted without danger of cutting.

(14.) That in spur gearing the chief loss from friction is in the journals, which should therefore be carefully designed; that the same is true in the case of worm gearing, but that it is still more important in the latter to provide for the reduction of friction due to the end-thrust on the worm shaft.

(15.) That the coefficient of friction (φ) of the spiral pinion and the worm, including step friction, ranges from two to nine and one-half per cent. (See table on page 463, vol. cxxi, J. F. I.)

The importance of the above determinations admits of no question, and will be apparent to any one who has ever given consideration to the subject to which they relate. The application of them, and of their summarized results, as shown in the tables on pages 453 and 463, and in the diagrams of efficiency (*Fig. 99*), will be of the greatest service in adapting gears of any kind to any particular use, and this is especially true in the case of worm gearing—wherein heretofore the limiting conditions have been but little understood.

As a further contribution on this subject, I will now describe the results obtained from a series of experiments made at the instance of the writer, for the Yale & Towne Manufacturing Company, by Professor R. H. Thurston, at Stevens Institute of Technology, in 1883–84.

In this case the gears experimented with consisted of a cast iron worm wheel of $15\frac{5}{16}$ inch pitch diameter, with 50 machine-cut teeth, $2\frac{1}{2}$ inch face; driven by a double-threaded cast iron worm, machine-finished, 6·1 inch pitch diameter, and 4 inches long on the thread. The velocity ratio was twenty-five to one. These gears were set in a suitable frame, and were driven by power transmitted by shafting and belting through a transmitting dynamometer, carefully standardized. The power transmitted from the gearing was taken off and measured by a Prony brake, also carefully adjusted. The tests were made with much care, and by competent observers, and were sufficiently numerous to give assurance of reliable results. The range of speeds covered by the experiments extended from forty-one to 339 revolutions of the worm per minute, and the variations in the amount of power transmitted

to the gearing ranged from ·2 to 4·14 horse-power. In each case, apparently, the experiments were carried up to and beyond the point of maximum efficiency, which latter was, of course, the determination aimed at in the investigation. The range of speeds above referred to gave velocities of the rubbing surfaces ranging from sixty-five to 538 feet per minute. The latter speed afforded clear indications that the point of maximum efficiency had been reached and passed, its location, under the conditions of the tests, being apparently at or about the point of 243 feet per minute of the rubbing surfaces (which is obtained at a speed of 140 revolutions of the worm per minute), a result strikingly corroborative of the work of Mr. Lewis.

Appended hereto are two tables, No. 1 giving the dynamometer readings, speeds and efficiency of the gears under varying conditions, and No. 2 showing a summary of the same, with the coefficient of friction as deduced therefrom.

By examining these tables, it will be seen that the ratio of power absorbed or lost in the gearing decreases with increasing velocity up to a maximum at the point where the velocity of the rubbing surfaces is 243 feet per minute. As the speed is further increased a decrease in efficiency occurs, thus indicating clearly the speed at which the gears experimented with, should be driven, in order to attain the highest efficiency in amount of power transmitted. Obviously the precise velocity of maximum effect will vary with the degree of pressure on the rubbing surfaces, and also, to a less extent, with the kind of lubricant used. In the present case the maximum obtained was with the highest pressure consistent with the general strength and rigidity of the apparatus, and with thorough lubrication with good sperm oil. It thus represents conditions which are probably the best ordinarily attainable, and the maximum efficiency thus indicated, while closely approachable, will rarely if ever, be exceeded in ordinary practice.

The results of the tests made by Professor Thurston, as above described, showed a lower efficiency of transmission from the gears than was expected, and this led to an investigation as to the causes of loss. Chief among the latter was evidently the absorption of power caused by friction due to the end-thrust of the worm against its bearing in the frame. To diminish the loss from this cause, the apparatus was thereupon provided with two forms of

thrust-bearing for the worm-shaft, so arranged that either could be readily applied and tested independently of the other.

As originally constructed, the end-thrust of the worm was taken directly from its hub upon a corresponding face or collar of the cast-iron box contained in the frame or housing, the width of this surface of contact being one inch, and its mean radius from the centre of the shaft or worm one and one-fourth inches. The two modified arrangements consisted:

(1.) Of what is usually known as the "button thrust-bearing, or step, in which the projecting end of the worm shaft is capped with a thin disc of hardened steel, the exposed face of which is slightly convex, and behind this is placed an adjusting set screw, with its hardened end abutting against the disc on the end of the shaft. In this case, the area of contact of the rubbing surfaces is the minimum which, with the metals used, will resist crushing under the thrust received. The radius of rotation is obviously also reduced to a minimum, and is very small. The whole bearing was kept well oiled.

(2.) Of an adaptation of the well-known roller thrust-bearing, consisting, in this case, of twelve chilled cast-iron coned rollers of nine-sixteenth inch mean diameter, contained within a brass cage having a separate pocket for each cone, the cones travelling, at a mean radius of one and three-eighths inches from the axis of the shaft, between two steel collars, or rings, one bearing against the hub of the worm, and the other against the face of the frame bearing, the faces of these rings being coned to the shape of the rollers. The centrifugal thrust of the cones was resisted by a wrought-iron ring surrounding the cage, the ends of the cones being convex.

The apparatus being thus modified, further tests were made, the results of which, in the case of the button thrust-bearing, are shown by Table No. 3, and in the case of the roller thrust-bearing by Table No. 4. A comparison of these with the preceding tables at once discloses the fact that the efficiency of the gearing is materially increased by both forms of thrust-bearing, a maximum of over sixty per cent. being obtained with the roller thrust-bearing, as compared with a maximum of forty-three per cent. with the original bearing. The efficiency of the improved apparatus is thus fifty per cent. greater than that of the original

arrangement, showing conclusively that a well-designed thrust-bearing is a most important feature in worm gearing for the transmission of power. Appended to this are diagramatic plottings of the several tests above described (*Figs. 137* and *138*), an examination of which will show a curious divergence in the curve of efficiency of the button, and of the roller thrust-bearings. This discrepancy, or divergence, led to some apprehension of an error in the tests, and to remove doubt on this point the experiments were repeated, but with no change in the results. It is probable, therefore, that under high pressures the roller bearing is subject to deformation, or other alteration from strain, which decreases its

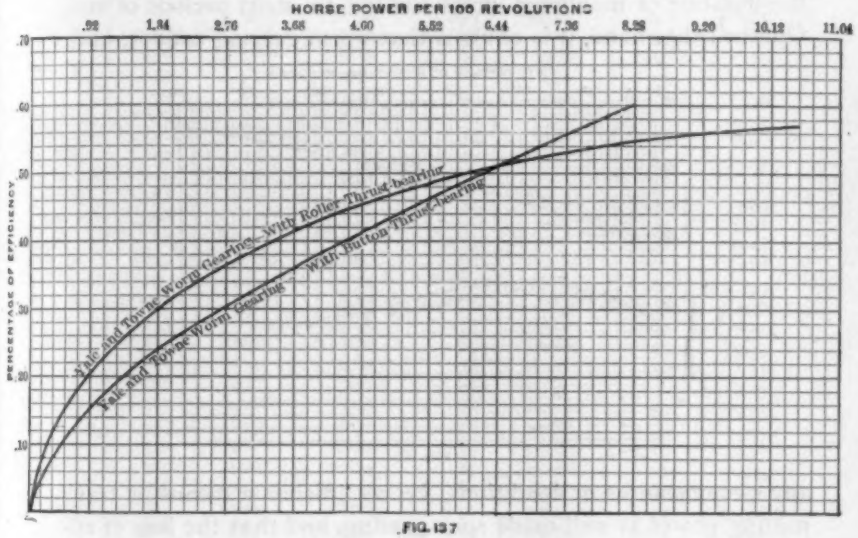


FIG. 137

efficiency, whereas the button bearing continues to gain in efficiency up to the point where cutting of the surfaces will begin. The general results of Professor Thurston's tests, as above referred to, are very clearly exhibited in the above diagrams, *Figs. 137* and *138*.

The results of the tests thus reported are strikingly confirmative of those made by Mr. Lewis, and all of the deductions which I have stated as to be derived from his work, apply almost equally to that of Professor Thurston. The chief importance of the latter, aside from its general confirmation of the former, is the clear indication it gives of the importance of providing for the end-thrust of

the worm much more carefully than has ordinarily been done. The experiments show that by a very simple provision of this kind the efficiency of the worm can be increased fifty per cent. Thus constructed, its absolute efficiency may be said to range from fifty per cent. to sixty per cent. of the power received, as compared to an efficiency of seventy-five per cent. to ninety-five per cent. in the case of the best cut spur gearing. Worm gearing thus becomes a permissible mode of transmitting power in many cases where a large velocity ratio is desired within a small space, where it is necessary to connect two shafts whose axes are at right angles, and especially where the duty on the gearing is intermittent and the duration of maximum stress limited to short periods of time. On the other hand, it is obvious that worm gearing cannot, under

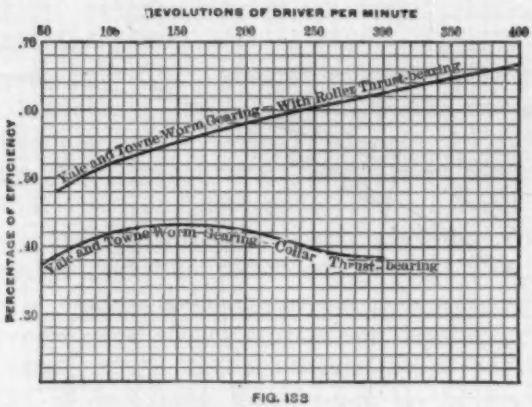


FIG. 133

any circumstances or conditions, be as efficient a means of transmitting power as well-made spur gearing, and that the loss of efficiency becomes very excessive when worm gearing is used at slow speeds. *These facts indicate clearly, therefore, that the use of worm gearing for transmitting power in machines moved by manual labor, and at slow speeds, should always be avoided, if possible.* In machines driven by steam, or other power, worm gearing is often a most convenient and useful substitute for spur gears, and, if properly designed and used, is not so much below the latter in efficiency as to cause any hesitancy in its employment. The proper methods of constructing and using worm gearing will certainly be better understood by a study of the investigations reported in the preceding pages.

TABLE No. 1.

YALE AND TOWNE WORM GEARING. WITH COLLAR THRUST-BEARING.

Reading on Dyn.	Rev's. of Dyn.	Rev's. of Worm.	Rev's. of Gear.	Pounds on 4 foot Arm.	Horse-power Received.	Horse-power given out.	Effic.
½	70	50·7	2·03	59	·252	·0914	·362
1	70	50·7	2·03	116	·417	·176	·422
1½	72	52·1	2·08	160	·599	·254	·424
2	70	50·7	2·03	213	·747	·33	·441
2½	66	47·8	1·91	250	·860	·264	·423
3	67	48·5	1·94	290	1·032	·429	·415
½	57	41·6	1·23	58	·205	·055	·268
½	108	78·6	3·14	61	·388	·146	·376
½	135	97·8	3·91	65	·486	·194	·399
1	54	39·1	1·56	92	·322	·109	·338
1	97	70·6	2·82	100	·578	·215	·371
1	122	88·7	3·54	106	·727	·286	·393
2½	157	116·	4·64	252	2·04	·892	·437
2	157	116·	4·64	212	1·67	·751	·449
1½	162	119·	4·76	157	1·34	·570	·425
1	168	123·	4·92	105	·995	·39	·391
1	162	117·7	4·7	119	·965	·427	·444
½	159	115·5	4·62	68	·572	·239	·417
1	197	143·1	5·72	121	1·174	·528	·449
½	212	153·9	6·15	71	·763	·333	·436
1	255	184·	7·36	123	1·519	·691	·454
½	285	206·5	8·26	69	1·026	·435	·423
¾	218	165·	6·64	91	1·04	·460	·435
¾	266	195·	7·80	87	1·27	·517	·417
½	285	206·	8·26	69	1·026	·435	·423
1½	333	243·	9·72	143	2·76	1·09	·395
1⅜	370	281·	11·24	155	3·26	1·36	·417
1¾	365	266·	10·64	167	3·03	1·221	·403
1⅞	395	283·	11·32	182	3·51	1·61	·458
1¼	393	280·	11·20	120	2·81	1·05	·373
1	318	233·	9·32	115	1·90	·85	·447
1¼	318	233·	9·32	134	2·27	·985	·434
1	308	225·	9·00	101	1·83	·717	·392
1	400	294·	11·76	98	2·38	·912	·383
¾	304	274·	10·96	85	1·79	·732	·409
1¾	464	339·	13·56	119	3·31	1·27	·384
1½	413	303·	12·12	139	3·44	1·33	·386
1⅝	465	337·	13·48	168	4·14	1·77	·427
1⅛	442	323·	12·92	152	3·58	1·52	·424
1½	453	331·	13·24	137	2·77	1·41	·375
1½	434	317·	12·68	130	3·61	1·3	·36
1	400	294·	11·76	98	2·38	·91	·382
1	436	826·	13·04	96	2·60	1·03	·396
⅛	439	320·	12·80	70	1·81	·72	·398

TABLE No. 2.

YALE AND TOWNE WORM GEARING. WITH COLLAR THRUST-BEARING.

Revolutions of Worm.	Velocity of Rubbing.	Horse-Power Received.	Efficiency.	Coefficient of Friction.
45·5	72·	·229	·347	·194
84·	132·8	·545	·383	·162
88·7	140·3	·727	·393	·159
118·	186·6	1·51	·425	·140
154·	243·6	·993	·440	·132
195·	308·5	1·27	·431	·136
226·	357·5	1·957	·418	·144
275·	435·	2·81	·405	·152
285·	450·8	2·83	·402	·154
315·	498 3	2·96	·390	·160
333·	526·8	3·45	·395	·158

TABLE NO. 3.

YALE AND TOWNE WORM GEARING. WITH BUTTON THRUST-BEARING.

Net W't in Pounds on Scale.	Rev's. of Worm.	Rev's. of Gear.	Reading of Dynam.	Rev's. of Dynam.	Horse-Power as per Dynam.	Horse-Power as per Brake.	Efficiency.
1·20	128·	5 12	·030	179·	·247	·005	·020
1·25	175·	7·00	·010	242·	·311	·008	·024
10·80	136·	5·44	·092	188·3	·315	·054	·170
10·80	128·	5·12	·030	180·	·248	·058	·234*
16·52	165·	6·60	·181	225·3	·472	·100	·212
16·54	196·	7·84	·240	268·3	·636	·119	·171*
17·35	140·	5·60	·203	192·3	·423	·092	·217
18·09	98·	3·92	·204	134·	·295	·068	·230
19·94	32·	1·28	·226	44·7	·103	·023	·223
36·50	356·	14·24	·393	462·7	1·432	·478	·334
37·66	175·	7·00	·377	234·	·706	·240	·339
39·06	310·	12·4	·443	63·	1·470	·444	·302*
39·07	136·	5·44	·355	188·3	·549	·190	·346
39·25	103·7	4·188	·338	141·7	·402	·150	·373
42·61	108·3	4·33	·407	148·3	·468	·170	·363
42·96	34·7	1·388	·214	47·	·106	·054	·509*
43·22	46·3	1·85	·443	63·	·210	·076	·361
49 55	176·	7·04	·280	242·	·619	·290	·471*
55·40	196·	7·84	·434	268·3	·882	·390	·442
64·18	128·3	5·08	·467	175·	·602	·299	·496
84·77	129·	5·16	·562	181·7	·707	·402	·568

* Doubtful.

TABLE No. 4.

YALE AND TOWNE WORM GEARING. WITH ROLLER THRUST-BEARING.

Net W't in Pounds on Scale.	Rev's. of Worm.	Rev's. of Gear.	Reading of Dynam.	Rev's of Dynam.	Horse-Power as per Dynam.	Horse-Power as per Brake.	Efficiency.
20·50	168	6·72	·123	231	·2404	·1267	·301
36·92	155	6·20	·265	214	·5328	·2105	·395
37·25	168	6·72	·255	231	·5645	·2302	·408
41·21	100	4·00	·324	138	·3820	·1516	·397
43·08	170	6·80	·310	233	·631	·2695	·427
49·40	170	6·80	·347	233	·6705	·3089	·460
49·89	197	7·88	·365	279	·826	·3616	·438
52·70	214	8·56	·459	297	1·011	·4149	·410
55·07	139	5·56	·433	194	·537	·2876	·535*
58·88	85	3·40	·503	118	·426	·1841	·432
60·23	182	7·28	·452	253	·8534	·4039	·473
65·36	319	12 76	·459	441	1·502	·764	·509
65·72	168	6·72	·503	231	·8348	·4061	·486
65·90	168	6·72	·507	231	·8410	·4069	·484
68·06	174	6·96	·491	238	·8466	·4386	·518
105·00	121	4·84	·869	167	·892	·4673	·524
110·59	320	12·80	·936	442	2·500	1·6048	·642*
115 07	156	6·24	·891	215	1·171	·6603	·5644
115·34	354	14·60	·793	488	2·509	1·5019	·598
119·26	260	10·40	·853	359	1·8905	1·1406	·603
121·48	217	8 68	·912	299	1·6578	·9666	·583

* Doubtful.

VIOLENT STORM.—During a violent storm at Torre-Cajetani, thirty-six frightened peasants took refuge in a house which was struck three times by lightning. Thirteen of them were killed, and the others were all wounded more or less severely.—*Cosmos, Aug. 10, 1885.*

DANGER FROM UMBRELLAS AT SEA.—In these days of electric lighting, one is often in the neighborhood of dynamos, and, however short the time of exposure to their influence, pocket knives and the steel in watches and umbrella frames may become powerfully magnetized. On board the *Princess Beatrice*, the helmsman lately observed that the compass was agitated. On examination, he found that the needle was affected by the magnetized steel mounting of a parasol in the hands of a lady who was walking upon the bridge. If the lady had been at rest, so that nothing would have shown the abnormal deviation, the ship might easily have been steered out of its course and thus been exposed to dangerous accidents.—*Cosmos, Oct. 12, 1885.*

The MICROSCOPIC STRUCTURE of CAR WHEEL IRON.

By F. Lynwood Garrison, F.G.S.

[*Read at the Pittsburgh Meeting of the American Institute of Mining Engineers,* February, 1886.*]

The study of the microscopic structure of the iron of car wheels, which it is the aim of this paper to describe, was made at the suggestion of Dr. Dudley, whose paper upon the constitution of cast irons precedes, and should be read in connection with, this one. Although the two wheels referred to in that paper possess nearly an identical ultimate chemical composition, they possess, as Messrs. Dudley and Pease have shown, physical properties so widely different, as to make one of them nearly worthless for the purpose for which it was cast. Considering the chemical similarity, such a marked difference in strength cannot but be very striking, and goes to show how little reliance can be placed upon chemical analysis alone, if *not properly interpreted.* I say "not properly interpreted," because I believe that very few analyses of iron or steel are thus fairly dealt with. That an analysis may read so much of one thing and so much of another, tells us very little as to the properties of the metal; for these are determined to a large extent by the conditions and relations in which the elements are present. To the unaided eye the difference between the two wheels under consideration is not striking. The inferior one would be described as light gray, and the other as somewhat darker. Upon careful examination of an etched fragment, however, the difference in structure will be found to be very marked, as may be seen in *Figs. 1* and *2* (produced from photographs by the Ives process).

It is exceedingly difficult to produce a photograph giving a fair notion of the appearance of the metal under the microscope, so as to give to persons not familiar with microscopical study, a proper appreciation of what a microscopist would consider a decided difference in structure. I would, therefore, urge any one especially interested in this subject, not to depend upon the photographs of

* From advance sheets of the *Trans. A. I. M. E.*

others, but to prepare and etch the specimens himself, and then examine them with a good microscope.

As is well known, iron possesses the property of uniting with a number of elements, forming products which are either highly intimate mixtures of several substances, or else compounds of an indefinite character. Indeed, such mixtures may be regarded as alloys, or as Matthiessen puts it, "solidified solutions of one substance in another." Of all the elements commonly associated with iron, carbon and, possibly, silicon have the peculiar property of being capable of existing in the compound in two distinct conditions, one in an amorphous or combined state, and the other as graphite in mechanical mixture with the iron. From the recent researches of Sir Frederick A. Abel,* Dr. C. B. Dudley, and F. N. Pease, of Altoona, Pa., there seems to be much to strengthen the belief of the existence of carbon in iron in a third and combined form, as a "carbide of iron." This compound is described as a "definite product capable of resisting the oxidizing effect of an agent which exerts a rapid solvent action upon the iron through which this carbide is distributed. It is gray in color, and seems to exist in small granules, affecting the continuity of the metal."

That such a compound of carbon and iron exists as such in the metal, is by no means proved; and so far as the writer's researches with the microscope have extended, there seems to be little evidence for or against such a hypothesis. It is a generally accepted belief that, when present in considerable quantity, graphitic carbon has a decided effect in decreasing the strength of cast iron. Such is certainly the case when a certain limit has been passed; but just what this limit is, it would be difficult to determine. It is very probable, however, that this limit is affected by the amounts of other elements present, and by the conditions under which the metal has been fused and cooled, or treated at a temperature below its melting point. Thus it is found that hardened steel yields no sensible residue of graphite when dissolved in acids; but if, on the other hand, the same steel be annealed, a very considerable amount of graphitic residue will be obtained. It also seems that a temperature much higher than that of the melting point of the metal is necessary to produce graphitic

* *Journal of the Iron and Steel Institute.*

iron, and that slow solidification after fusion is the condition most favorable to the separation of the graphite in flakes or laminæ. On the other hand, rapid solidification or chilling favors the retention of the carbon in the combined or amorphous state, and produces a hard, white, and highly crystalline iron, melting at a temperature considerably lower than gray iron. When the amount of manganese present is relatively large, the separation of graphitic carbon takes place to but barely an appreciable extent, the resulting mass, after fusion and solidification, being highly crystalline, and with fractured surfaces of great brilliancy, whence the name of spiegeleisen.

It seems almost certain that there exists no ordinary iron or steel in which *all* the carbon is contained in either one condition or the other, but that it always exists in the two (or three) conditions together, and that upon the relative proportions of these depends, in great degree, the quality of the metal. Thus in cast iron, if the relative amount of combined carbon is large, we have a white iron, but if small, a gray graphitic iron with quite different physical properties. Car wheels being made usually from the best grades of pig iron can be described as gray iron, the periphery or "tread" alone being white or chilled, and, of course, between the two, a small intermediate zone, containing varying proportions of combined and graphite carbon. In nearly all varieties of gray cast iron, a very marked and characteristic development of the graphitic carbon will be observed when a fragment of the metal has been carefully ground, etched, and microscopically examined. As will be shown below, the existence of the graphite in strong and well-defined lines and plates has a most important bearing upon the strength of the metal.

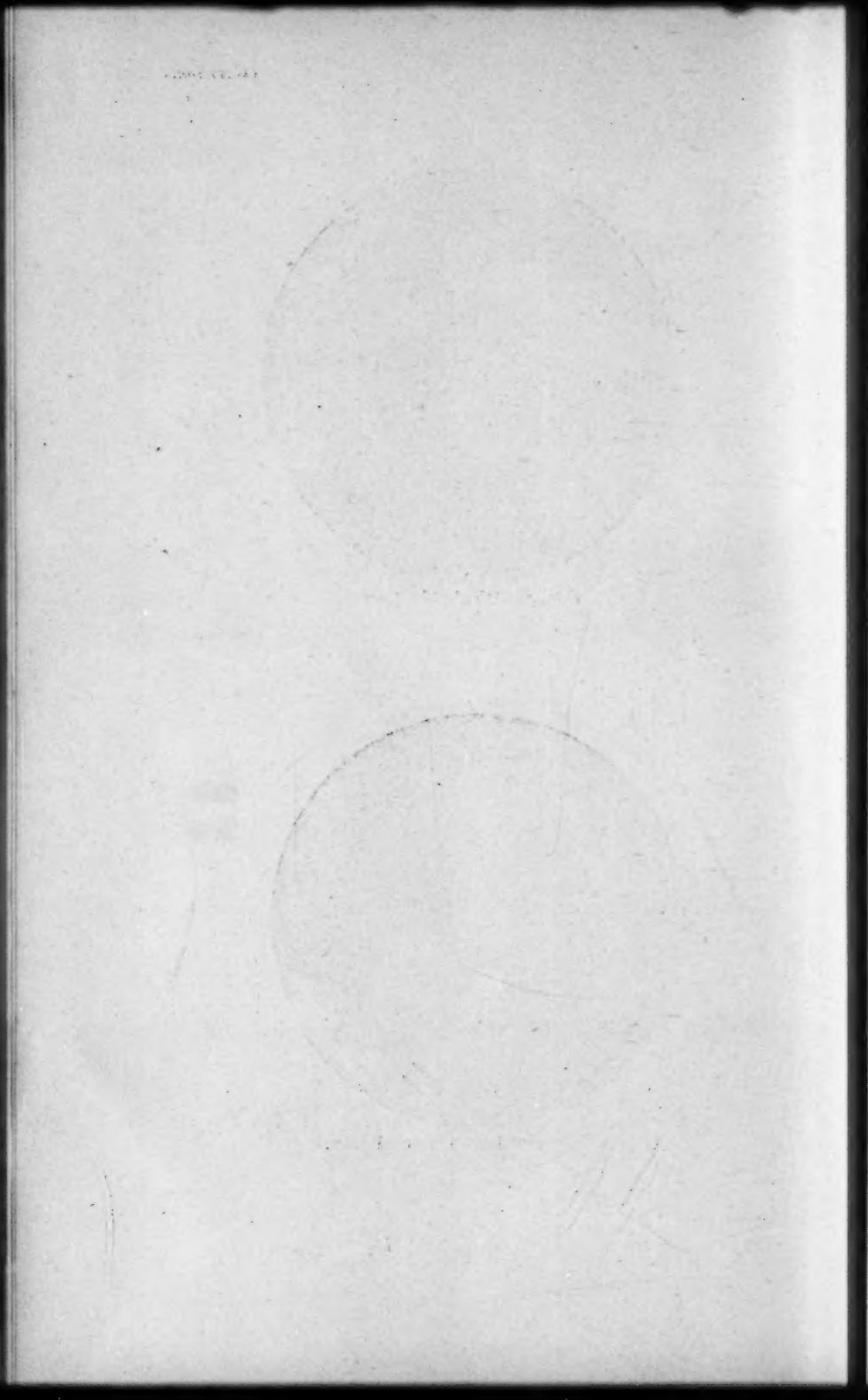
In *Fig. 1*, taken from a photograph showing the microscopic structure of the good car wheel iron, the plates and lines of graphite are very marked, and appear as an irregular mass of small black lines, which might be likened to a number of small black worms wriggling and squirming throughout the metal. The surrounding mass of metal presents a compact, granular, non-crystalline structure, frequently containing cavities, due to occluded gases or air. It seems impossible to produce castings altogether free from these defects—and it does not need always the microscope, or even a magnifying glass, to detect them—but it is doubtful

FIG. 1.—Good Car-wheel Iron.

FIG. 2.—Poor Car-wheel Iron.

FIG. 3.—Weak Pig Iron.

FIG. 4.—Hot-Blast Charcoal Iron.



whether their absence would prove of much benefit to the metal for practical purposes. On further examination of *Fig. 1*, it will be observed that very little of the graphite occurs in isolated irregular patches, as will be seen to be almost always the case in the poorer grades of cast iron.

In *Fig. 2*, we have the structure of the poor car wheel iron. It will be noticed that, although the mass of the metal itself appears to be the same as that of the good wheel, the well-developed and prominent graphite plates are absent, and are replaced by the graphite in irregular and somewhat isolated patches of comparatively large size, and without any regular grouping. This peculiarity seems general, and characteristic of the poorer grades of cast iron. In nearly all cases metal which shows it is unreliable, lacking the toughness and durability of the better grades.

In *Fig. 3*, is exhibited a similar structure, being that of a weak and almost valueless pig iron, containing 4·6 per cent. of carbon, 3·22 per cent. of which is present as graphite in irregular patches, as in *Fig. 2*, the metal mass itself being compact and granular.

In *Fig. 4*, is shown the structure of a high grade hot blast charcoal pig iron; the similarity of its structure with that of the good wheel is quite apparent, except that in the latter the graphite plates are somewhat larger and more prominent.

These facts indicate that the development and distribution in well-defined lines or plates of the graphite carbon is at least as important a factor of quality, up to a certain limit, as its total amount. Although it is generally supposed (and undoubtedly with good reason, when the limit has been passed) that the presence of graphite in quantity renders the metal weak, I have found, in almost all cases where the iron lacked strength, that the development of the graphite in plates was only incipient, and that the graphite present existed in irregular patches or clusters of great variety in size and shape.

Of course, this connection between the strength of the metal and the form and distribution of its graphitic contents, even if proved to be an invariable one, need not necessarily represent the only, or the whole, explanation of the case of the two car wheels now under consideration. Nor is the question answered, to what cause the difference in graphite distribution is due. Perhaps the following facts may throw some light upon the problem.

Percy * says, that the mode of existence of the carbon in iron and steel is, to a certain degree, determined by the conditions under which the solid metal has been heated and cooled at temperatures very much below its melting point. This point is best illustrated by the annealing of hard steel, and its subsequent treatment with acids, before alluded to. Again, according to Karsten, it seems that even if cast iron is allowed to cool with the utmost slowness after fusion, it is not then converted into gray iron unless it has been melted at a much higher temperature than was required to bring it to a liquid state.

The following are the analyses of the two wheels, as given by Messrs. Dudley and Pease:

	Good Wheel.	*Poor Wheel.*
Total carbon,	3·84 per cent.	3·53 per cent.
Graphite,	3·30 "	2·36 "
Combined carbon,	0·54 "	1·17 "
Silicon,	0·69 "	0·65 "
Phosphorous,	0·43 "	0·52 "
Manganese,	0·13 "	0·12 "
Sulphur,	0·12 "	0·19 "

From these analyses, it will be observed that the poor wheel contains 0·07 per cent. more sulphur than the other. Bell,† in speaking of the influence of sulphur upon cast iron, observes that, "speaking in general terms, it seems probable that the presence of this element interferes, in some way, with the separation of carbon in the graphitic state, a condition which appears essential to the formation of soft iron."

Although it may not apply in this particular case, it is a well-known fact that silicon, when present in considerable quantity, seems to favor the separation of graphitic carbon, and that the grayest iron is apt to be the richest in that element. As will be seen from Dr. Dudley's paper, the small difference in the amounts of phosphorus present in each wheel, does not, in all probability, affect the result, so that its presence need hardly be considered.

The above citations point to the conditions of fusing and cooling, and to the relative proportions of ingredients other than carbon, as controlling the separation of graphite. Dr. T. M. Drown‡

* *Metallurgy of Iron and Steel.*

† *Principles of the Manufacture of Iron and Steel*, p. 103.

‡ *Transactions*, vol. viii, p. 41.

has suggested a very beautiful hypothesis, according to which the amount of graphite separated in any given instance is proportional to the time consumed by the pig iron in passing through a limited range of temperature, probably near the point of solidification. Adopting this hypothesis, may we not further imagine that the other ingredients, affecting the melting point of the compound, affect also the limits of this range of temperature; but that, these things being equal (as they almost are in the case before us), the conditions of casting and cooling may decide the quality of the product, by determining not merely, as Dr. Drown suggests, the amount, but also the form and distribution of the segregated graphite?

THE REFRIGERATION MACHINE AS A HEATER.

BY GEORGE RICHMOND.

Although the isentropic transfer of heat is usually impossible, yet we can approach as nearly to it as we desire, and the results based on the assumption of sources of heat of unlimited extent can be realized as nearly as practical construction can bring us to the limiting condition. Thus if we have an infinite supply of heat at T^0 we can transfer a finite quantity at T^1 very near to T^0 without sensible increase of entropy, and the practical limit of such a process is only reached when the value of the energy saved from dissipation is less than that required by the mechanism to effect the contact. On this understanding, the following discussion considers only the limiting case.

Suppose we have a quantity of heat Q_1 at temperature T_1 (absolute). By simple transfer (using the ordinary irreversible processes of conduction or radiation) to a lower temperature T_2 the quantity of heat remains unchanged, but the entropy is increased.

$$Q_1 \left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad (1)$$

and the available energy between T_1 and T_2 is entirely dissipated.

But if this heat Q_1 is passed through a heat engine in accordance with the second law of heat, we have an isentropic transfer of heat to T_2, amounting to

$$Q_1 \frac{T_2}{T_1} \tag{2}$$

and a quantity of work, of which the heat equivalent is

$$\frac{Q_1}{T_1}\left(T_1 - T_2\right) \tag{3}$$

Suppose T_3 (lower than T_2) the temperature of surrounding object or the *highest* unlimited source of heat available for a reversed heat engine, and let the work (3) be employed in such an engine to effect a transfer of heat from T_3 to T_2, the amount thus transferred is

$$\frac{Q_1}{T_1}\left(T_1 - T_2\right)\frac{T_2}{T_2 - T_3} \tag{4}$$

We have, therefore, at T_2 an amount of heat represented by the sum of (2) and (4), or

$$Q_1 \frac{T_2}{T_1}\left(\frac{T_1 - T_3}{T_2 - T_3}\right) \tag{5}$$

which is always greater than Q_1, the original amount of heat employed. The relative effect of the mutual relation of temperature is more clearly seen by putting (5) in the equivalent form

$$Q_1 \frac{T_2}{T_2 - T_3}\left(1 - \frac{T_3}{T_1}\right) \tag{6}$$

from which we see that the transferred heat rapidly increases, as T_2 is more nearly T_3, and also increases but less rapidly as T_1 is removed from T_3. Moreover, if T_1 and T_3 are fixed temperatures, the intermediate temperature T_2 must be chosen as near to T_3 as practicable.

As an example, let

$$t_1 = 300^\circ \text{ F.}; \quad t_2 = 100; \quad \text{and } t_3 = 60.$$

The heat rendered available by this process is

$$Q_1 \times \frac{560}{760} \times \frac{240}{40} = 4\tfrac{8}{19}\, Q_1$$

or more than four times the heat originally employed. In other words, one pound of steam at 300° F. would heat as much water to 100° F. by this process as four pounds would by mere conduction, provided the highest available temperature were 60° F.

During this process, the entropy has remained constant and,

consequently, the available energy unchanged. We are not, therefore, liable to imagine that this large amount of low temperature heat could be used to run a heat engine to give a better result than the simplest cycle, namely, from T_1 to T_3. In fact, if we use this heat in (6), to run a heat engine between T_2 and T_3, the heat equivalent of the work done is

$$Q_1 \frac{T_2}{T_1} \left(\frac{T_1 - T_3}{T_2 - T_3} \right) \frac{T_2 - T_3}{T_2} = \frac{Q_1}{T_1} (T_1 - T_3) \qquad (7)$$

or precisely the same as that of working the engine between T_1 and T_3.

But suppose the object of the combination is to lower the temperature of surrounding objects, say to T_4; in other words, to run a refrigerating machine in the most economical manner. Since for this purpose the complex cycle above described exists, it would seem possible to utilize the heat generated by the compressor or reverse engine to assist the direct heat—or steam engine.

The sum of the rejected heat of the heat engine; and that transferred by the reverse engine (which latter quantity includes the work which is re-converted into heat); is now

$$Q_1 \frac{T_2}{T_1} \left(\frac{T_1 - T_4}{T_2 - T_4} \right) \qquad (8)$$

which is less than in the previous case, since T_4 is less than T_3. It is, however, much greater than the simply rejected heat of the engine at T_2, and might justify the employment of an agent to run an engine between T_2 and T_3. Such an engine would develop work equal to

$$Q_1 \frac{T_2}{T_1} \left(\frac{T_1 - T_4}{T_2 - T_4} \right) \frac{T_2 - T_3}{T_2} = \frac{Q_1}{T_1} \frac{(T_1 - T_4)(T_2 - T_3)}{T_2 - T_4} \qquad (9)$$

which would be available for running the compressor in addition to the original work, $\frac{Q_1}{T_1} (T_1 - T_2)$ of the steam engine.

As an illustrative example, let $t_1 = 300°$; $t_2 = 100$; $t_3 = 60$; $t_4 = 0$; that is, the engine is run between t_1 and t_2, the refrigerating machine between t_2 and t_4, and the low temperature engine between t_2 and t_3. The work of the steam engine is

$$\frac{Q_1}{T_1} (T_1 - T_2) = \frac{200}{760} Q_1 = \tfrac{5}{19} Q_1$$

and that of the low temperature engine

$$\frac{Q_1}{T_1}\frac{(T_1-T_4)(T_2-T_3)}{T_2-T_4}=\frac{300\times 40}{760\times 100}Q_1=\tfrac{3}{19}Q_1.$$

Here the work available for running the refrigerating machine is increased sixty per cent. If the steam engine had been able to utilize the heat down to t_3, the work done would be

$$\frac{Q_1}{T_1}(T_1-T_3)=\tfrac{6}{19}Q_1$$

the additional work due to the heat from the refrigerating machine giving an increase of fifty per cent. upon this. If this heat were really available, it might well be worth the expense of putting in a low temperature engine to utilize it. But this result could not be practically realized with advantage, for even if we admit that T_3, the refrigerator of the low temperature engine being unlimited, would remain constant, yet the economical working of the refrigeration machine requires that the temperature of its condenser, T_2, should be kept as low as possible; that is, as near to T_3 as practicable. Hence the factor (T_2-T_3) in (9) vanishes, and with it vanishes the possibility of employing the heat transferred by the refrigeration machine to assist it. We are confirmed in this conclusion if we observe the effect upon the efficiency of the refrigeration machine, which results from changing T_2 to T_3. The production is increased from $\frac{T_4}{T_2-T_4}w$ to $\frac{T_4}{T_3-T_4}w$, where w is the same amount of work employed in each case. In the example considered the production is increased in the ratio $\frac{T_2-T_4}{T_3-T_4}=\frac{100}{60}=1.66$, or sixty-six per cent. While, therefore, it is possible to utilize the heat transferred to the condenser of the refrigerating machine, if the temperature is sensibly raised, to restore the loss caused by such rise of temperature, it is better to provide ample surface and active circulation to effect the transfer at the lowest possible temperature.

Although it is thus evident that this complex cycle cannot be made use of to increase the efficiency either of the steam (or other heat) engine or its reverse, the refrigeration machine, there yet remain two cases in which the indications of practical utility are sufficient to merit consideration.

(1.) Where the object in view is to obtain low temperature heat from a high temperature source.

(2.) Where the object is to extend the cycle of operation beyond the temperatures readily controlled by the ordinary form of heat engine.

It is obvious that the impossibility of practically realizing completely either portion of this complex cycle will prevent our obtaining results equal to those indicated. But it may be noticed that in the present case the losses arising from defects are not the same as in the case where the object sought is the conversion of heat into work. Thus, for example, the loss arising from the incompleteness of the cycle by reason of which we fail to convert the available heat energy into work, is not a total loss to us, but remains as heat, and so much of such available heat as is converted into work will effect, under favorable conditions, the transfer to the condenser of the reverse engine of a much greater amount than the converted heat, even though the reverse cycle be itself imperfect. This is evident from the fact that the heat so transferred is the sum of the heat equivalent of the work (which is reconverted into heat) and whatever refrigerating effect may be produced.

Hence, a refrigerating machine may be employed as a heating machine, and the simplest explanation of this fact is that it utilizes the available energy of high temperature heat (which is dissipated in the usual mode of heating) to effect the transfer of another quantity of heat from surrounding objects.

The obstacles to an increased range of temperature in the heat engine, and consequent increased efficiency are due almost entirely to mechanical difficulties. It is conceivable that a means of practically effecting the transfer of heat considered from a temperature beyond the control of the present form of heat engine, to one within its range may be found which will not involve the mechanical difficulties of the present heat engine. The effect of this would be to render the efficiency of an engine working between T_2 and T_3 equal to that working between T_1 and T_3, and the possibility of accomplishing this gives an interest to the second case.

As a matter of fact, we have an example of a transfer of heat approximately at least, in accordance with the cycle considered in the closed distillation process which practically combines an

engine and its reverse. In this apparatus the heat received by the condenser is the sum of that taken from the refrigerator and that part of the heat supplied by the still, which corresponds to the available energy of the steam engine, while that portion, also supplied by the still, which corresponds to the rejected heat of the engine, appears in the absorber. The moving parts in this mechanism are insignificant and, but slightly, if at all affected by the range of the cycle, being merely a pump to effect the transfer of the agents used from the absorber to the still. Moreover, since the losses arising from the difficulties of adapting the mechanism of the heat engine to the cycle of maximum efficiency, together with those arising from the dissipation of energy in running the same are absent we may expect a greater practical efficiency. A still greater efficiency may be looked for from the fact that the range of the cycle is not limited by the same conditions which are imposed by the ordinary form of heat engine. The only apparatus of this description with which we are practically acquainted is the ammonia distillation machine. It is possible that in very cold climates a combination of this with a single low temperature engine would be simpler than that of a high and low temperature engine, although as shown the theoretic efficiency of each combination would be the same. But for extending the cycle in the other direction where the option of employing two heat engines is less practicable, we are at present unacquainted with suitable agents.

MEASURE OF LIQUID RESISTANCE BY ALTERNATIVE CURRENTS.—Two methods have been employed for the exact measurement of the resistance of liquids; one, based upon the use of electrometers with an elimination of the influence of the polarization of the electrodes; the other, consists in weakening the polarization so that it may be disregarded while augmenting at the same time the useful surface of the electrodes, and having recourse to alternative currents of the shortest possible duration. This method has been often employed abroad, especially by F. Kohlrausch. Bouty and Foussereau have compared the results by the two methods, using a small Deprez motor with a velocity of 100 turns per second, directing the currents to a Wheatstone bridge, in which the galvanometer was replaced by an excellent Ader telephone. They find the precision of the measurements with electrometers much the most satisfactory. It seems, indeed, very difficult to apply with any success the method of alternative currents to liquors which are greatly diluted, or which present great resistance.—*L'Electricien, Aug. 15, 1885.*

A METHOD OF DESIGNING SCREW PROPELLERS.

By Christian Hoehle, Philadelphia, Pa.

In bringing my method of designing screw propellers before the engineering public, I do so with the conviction that the principles embodied in it are entirely novel and original, and that they will greatly aid in solving all questions relating to a subject on which so much has been said, written and experimented, and of which, according to all authorities, so little is yet known.

In the calculations necessary to determine the proper dimensions of a screw propeller for producing at a given velocity a thrust equal to the resistance of the vessel, a certain amount of slip is at present arbitrarily assumed. And it so happens that later on during the running of the vessel the actual slip very rarely, if ever, agrees with the assumed slip; in fact, the difference between the two is generally very marked. Marine engineers have so far been unable to account for this perplexing difference for the simple reason, that they have not yet recognized on what properties of a screw propeller the slip depends. To point out these qualities and show how to obtain them is the main object of this article.

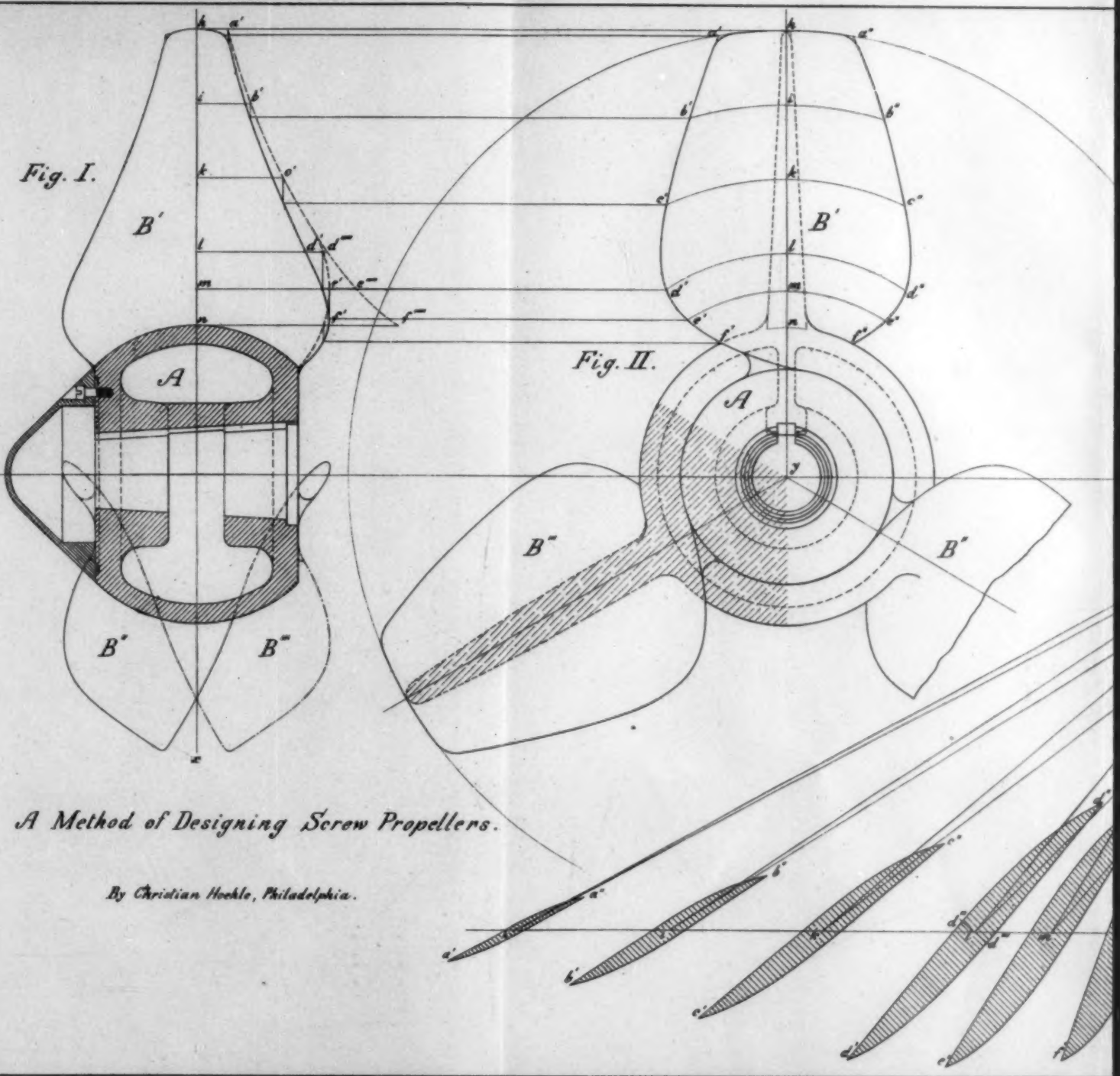
I believe everybody will agree with me when I assume that a good screw propeller, when driving a vessel, should affect only a column of water of a diameter equal to its own. For simplicity's sake, I will also assume that the vessel does not drag, so to speak, a body of water along with it and that therefore the velocity of the water approaching the screw is equal to that of the vessel. The difference of the disc area of the screw and its sectional area, as produced by a plane perpendicular to the axis at the centre of the hub, I call the opening of the screw. For a *properly* designed screw propeller, I now advance the proposition that *the velocity of the water passing through the opening of the screw is to the velocity of the vessel as the disc area of the screw is to the area of the opening.* And as the velocity of the water passing through the opening of the screw is equal to the velocity of the vessel plus the slip of the water, the above proposition may also be put into the following shape: *The slip of the water is to the velocity of the vessel as the sectional area of the screw is to the area of its opening.*

From these propositions it is at once apparent on what properties of a screw the slip depends.

I have said, however, that these propositions can be applied only to a *properly* designed screw, by which I mean one whose pitch increases from periphery to hub in a manner that with the aid of the accompanying drawing, I will now proceed to explain.

Fig. 1 represents a longitudinal section of a three-bladed screw propeller of my system; *Fig. 2* an end view of the same, showing also in dotted lines one-third of its sectional area as defined above and in blade B' its thickness at different radii. *Fig. 3* represents in a plane the cylindrical cross-sections of a blade at different radii, their respective pitch angles and the mode of determining them.

In *Fig. 3*, let $l\,g$ represent one-third of the circumference of a circle described with the radius $y\,l$ (*Fig. 2*) and let it also represent the circular velocity of the point l (*Fig. 2.*) On the same scale, let $g\,o$ represent the velocity of the vessel and $o\,p$ the slip of the water proportioned in accordance with the propositions presented above. Then I draw the two straight lines $l\,9\,4$ and $l\,t$ so that the line $l\,9$ is equal to the line $l\,t$, and so that the perpendicular $g\,25$ is equal to the perpendicular $g\,26$ plus the thickness $d'''\,d''''$ of the blade at the point l. Then $g\,t$ represents the velocity of the water on entering the screw. The resultant $l\,t$ of the two velocities $g\,l$ and $g\,t$ indicates the velocity of the water entering the screw obliquely, it remains constant while passing through the screw, but has its direction changed from $l\,t$ to $l\,9$. To recapitulate: the water approaches the screw with the velocity $g\,o$, enters it with $g\,t$ and passes through it with $g\,p$. The pitch angle of the cross-section in question is indicated by the angle $g\,l\,4$ and one-third of its pitch by $g\,4$. The perpendicular $g\,26$ represents the width of the *oblique* opening between two adjoining blades. By performing the above operation for the points h, i, k, l, m and n, I get their respective pitch angles $g\,h\,1$, $g\,i\,2$, $g\,k\,3$, $g\,l\,4$, $g\,m\,5$ and $g\,n\,6$; one-third of their respective pitches $g\,1$, $g\,2$, $g\,3$, $g\,4$, $g\,5$ and $g\,6$, and their respective widths of oblique opening $g\,20$, $g\,22$, $g\,24$, $g\,26$, $g\,28$ and $g\,30$. The velocity $g\,v$ with which the water enters the screw at the hub must never be less than the velocity $g\,o$ of the vessel. According to my method, therefore, *the pitch of a properly constructed screw propeller is smallest at the periphery and increases towards the hub, gradually at first and then more decidedly*



A Method of Designing Screw Propellers.

By Christian Hoehle, Philadelphia.

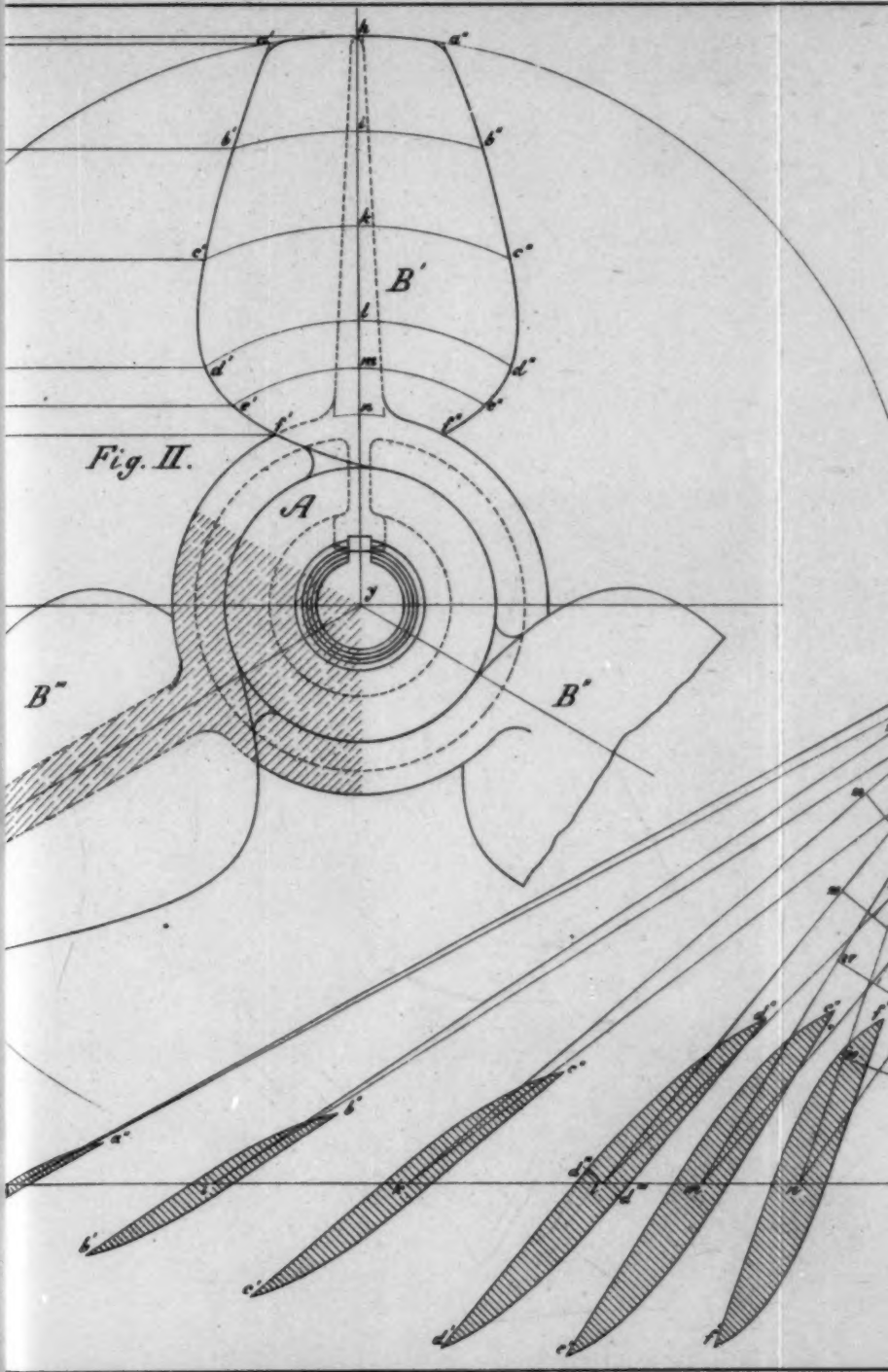


Fig. II.

Fig. III.
Disc area of screw propeller / Opening of screw propeller = Speed of vessel + Slip of water / Speed of vessel
Sectional area of screw propeller / Opening of screw propeller = Slip of water / Speed of vessel
Slip of water
Speed of vessel

as the hub is approached. The slip of the water, as I have called it, is indicated by *o p* and is the same at all points of the blade, while the slip of the screw as usually understood varies with the pitch, and for the points *h*, *i*, *k*, *l*, *m* and *n* is represented by *o 1*, *o 2*, *o 3*, *o 4*, *o 5* and *o 6*. The two kinds of slip differ but very little at the periphery, and when speaking in a general way of the pitch and slip of my screw propeller, I mean those at the periphery.

If for a screw propeller, with a uniform pitch from tip to hub, the velocities with which the water enters the screw at the different points are ascertained according to my method, it is found that at the hub this velocity is considerably smaller than that of the vessel; in other words, it is reduced to allow the water to pass through the *contracted* oblique opening of such a screw. And this means that, with a uniform pitch, the parts of the blades nearest the hub not only do not produce any thrust, but actually create resistance. *A screw propeller with a uniform pitch is a bad one.*

The lines forming the cross-section, $d'\ d'''\ d''\ d''''$, consist of two straight lines, $d'\ d'''$ and $d''\ d''''$, parallel with the pitch line *l 4*, and the two curved lines, $d'\ d''''$ and $d''\ l'''$; the straight lines being tangent to the curved ones at the points d''' and d''''. According to the material of which the screw propeller is made, the curved lines are more or less flat and the edges d' and d'' more or less pointed. By forming the cross sections of the blades in this manner, the water is free to leave the screw in the same direction and with the same velocity that it entered, a point that I consider absolutely necessary for the efficient action of a propeller. It has been pointed out to me that this cross section of mine is the only weak point in my system, and that I cannot possibly produce any thrust with it, an objection which I meet with the fact that the very action I aim to produce in my screw propeller takes place in paddle wheels, both radial and feathering, and yet we all know that these contrivances answer their purpose admirably.

I now come to the question of blade-surface and its disposition. By again referring to *Fig. 3*, it is seen that the velocities of the water, while passing through the screw at the points *h*, *i*, *k*, *l*, *m* and *n*, increase by the amounts *q p*, *r p*, *s p*, *t p*, *u p*, and *v p*. Now the time necessary to produce these increases in the velocities is, according to the laws of uniformly accelerated motion, directly

proportional to them, and therefore determines the relative lengths (parallel with the axis) of the blade at the different points. These half lengths are represented by *v 13*, *u 14*, *t 15*, *s 16*, *r 17* and *q 18*, and, on being transferred to *Fig. 1*, produce the curved line *a' b' c' d'''' e'''' f''''*, which, in order to meet the hub, I change to *a' b' c' d' e' f'*. I am not a mathematician, but I am perfectly aware that this last demonstration of mine is not mathematically correct, but I believe it to be sufficiently so for all practical purposes.

In conclusion, I frankly acknowledge that I have neglected to take into consideration several very important matters, namely, the shape of the vessel, the thickness of the stern and rudder-posts, and the diameter of the hub of the sternpost. At present I am unable to say in what way and to what extent they would tend to modify my system of constructing screw propellers. Neither did I take any notice of the friction caused by a screw in passing through the water, as I believe that by designing a screw propeller otherwise rationally, more will be gained than can possibly be lost by friction.

ROPE RAILWAY AT GENOA.—A rope railway is to be built at Genoa, from Balzaneto to the sanctuary of the Madonna de la Garde. Instead of a stationary engine which acts directly upon the endless cable, the locomotive which conducts the train from Balzaneto to the foot of the hill will be detached, and its wheels will serve as pulleys for the cable. It is thought that this arrangement will be much more economical than that of a stationary engine, which would necessarily have a horse-power greater than would often be needed.—*Cosmos, Sept. 28, 1885.*

SPECTRAL ANALYSIS OF ATMOSPHERIC ELEMENTS.—The study of the spectra of the atmospheric gases and vapors is of especial importance in astronomical physics in as much as it furnishes one of the principal bases for inferences as to the composition of planetary and stellar atmospheres. The Meudon observatory has great facilities for the employment of solar, electric and other lights, and for arranging in a single hall a series of experiments 120 metres long. Janssen is experimenting upon hydrogen, oxygen and atmospheric air in four tubes, all of which are strong enough to support pressures of nearly thirty atmospheres, and one of which is sixty metres long. In addition to the lines and bands which were first pointed out by Egoroff, he has already found absorption phenomena beyond A., and three obscure bands, one in the red, one in the yellowish-green and one in the blue, which can hardly be attributed to the oxygen in the condition in which it exists in the terrestrial atmosphere.—*Comptes Rendus, Oct. 5, 1885.*

CORRECT COLOR-TONE PHOTOGRAPHY WITH ORDINARY GELATINE BROMIDE PLATES.

By Fred. E. Ives.

[*Paper read at meeting of* Franklin Institute, *June 16th. Revised and presented for publication June 18th.*]

Chlorophyl-stained collodion bromide emulsion plates have been made four or five times more sensitive to spectrum red than to blue. It has been estimated that ordinary gelatine bromide plates are 100 times more sensitive to blue than to red. The *relative* red sensitiveness of the chlorophyl-stained collodion plates is, therefore, probably 400 or 500 times greater than that of ordinary gelatine bromide plates. But the most rapid ordinary gelatine bromide plates are 100 times more sensitive to ordinary diffused daylight than the collodion emulsion plates, and it would, therefore, appear that the absolute red sensitiveness of the very rapid gelatine plate should be one-fifth as great as that of the very slow chlorophyl plate. By recent experiment in photographing the lime-light spectrum, I have found this estimate to be very nearly correct for some makes of extra rapid gelatine bromide plates.

What, then, is to prevent us from making correct color-tone photographs with very rapid ordinary gelatine dry plates? The difficulties, although apparently great, are not insurmountable, as I shall show; but the exposures are necessarily so long that the method is not available in many cases where the regular isochromatic processes can be successfully employed. I have calculated that, in order to secure correct color-tone without a color-screen, it would be necessary to have plates about ten times as sensitive to spectrum red as to blue; if this estimate is correct, the ordinary rapid gelatine dry plate is relatively 1,000 times too sensitive to blue, and in order to secure correct color-tone with such a plate it would be necessary to cut off $\frac{999}{1000}$ of the blue light, and green and yellow in due proportion. It is very easy to cut off a large portion, or all, of the blue light, but it required a great deal of patient experiment to produce a color-screen that cut off just enough of the blue, and also of the green and yellow. I accom-

plished this by a mixture of aniline color solutions in the plate-glass tank which I recommended for color-screen purposes, in 1879. My first trial exposures were made on the lime-light spectrum. I commenced by adding aniline yellow to water in the tank, a little at a time, until so little blue light was transmitted that it produced very much less action than the red; I then added aniline red until the green acted but little more than the blue, and aniline violet to slightly reduce the action of the yellow. An exposure made in the camera, using this color-screen and a M. A. Seed plate, proved that my calculations were very nearly correct. I was only obliged to add a little more yellow and red to the color solution to secure correct color-tone in all the colors of a bright chromo, which I use as a test object. *With exposures five times longer*, I have secured results apparently equal to those obtained with my chlorophyl-eosine plates and yellow screen.

The result which I obtained cannot be even approximated by means of a screen of any single-color solution that has been tried, and I believe this to be the first specification of the production of a color-screen actually capable of securing correct color-tone with ordinary plates.

RELATION OF VAPOR TENSION TO INTERNAL FRICTION.—The phenomenon of diffusion and the displacements of minute particles which are introduced into liquids show that liquids are formed of molecules, which are endowed with a perceptible movement of translation. Vaporization is, therefore, easily explained by attributing to some of the molecules a *vis viva* sufficient to project them beyond the sphere of activity of the superficial molecules. If we adopt this explanation, the vapor tension must be intimately connected with the molecular velocities, which are themselves a function of the coefficient of internal friction. P. De Heen has found an empirical formula, which represents very closely this theoretical ratio in all the bodies upon which he has experimented. Designating by p the vapor tension taken at the absolute temperature T, and by f the coefficient of friction at the same temperature, we have $Tf \log. p = \text{const.}$—*Bul. de l'Acad. de Belg., No. 8, 1885.*

GEOLOGICAL THERMO-CHEMISTRY.—In order to determine the influence of thermo-chemistry in the production of metallic ores, Dieulafait assumes that if we study each metal and find which of its natural combinations develops the greatest heat, that combination will be found to represent the principal ore of the metal under consideration. He has tested his theory by the four most frequent ores of manganese, and finds it to be satisfactorily confirmed. —*Comptes Rendus, Oct. 5, 1882.*

SUGGESTIONS TOWARDS A SIMPLIFIED SYSTEM OF WEATHER SIGNALS, TERMED THE INDEX WEATHER SIGNAL SYSTEM.

By Joshua Pusey.

[*Presented at the Stated Meeting of the* Franklin Institute, *held June 16, 1886.*]

In the effort to learn and to recollect the well-known weather signals now in use, consisting of the red and blue suns, stars and crescents, I was struck, as others have doubtless been, with the difficulty of fixing and retaining the same in memory because of the confusion of arbitrary colors and forms. It occurred to me that a system might be devised which would possess the salient advantages of being simpler, independent of essential color and form, readily learned and recollected, and more economical than the system now in vogue.

My reflections upon this subject led me to devise the system which I shall now proceed to describe, premising, however, that, although it is not claimed to be perfect, it is thought to be better than that in use.

In this system, movable signal bands are used in connection with a flag, or rotatable pointers pivoted on a common centre, as hereinafter described.

Referring to the drawings, *Fig. 1* represents a flag, *A*, preferably white, having a vertical black stripe or bar *b* (termed the general rain or snow bar) at one side of the centre. The flag is always hung with this stripe in vertical position. The flag is divided into six (imaginary) fields, three of which are horizontal *temperature* fields and three vertical *weather* fields.

The top or higher part is the *higher* temperature field; the bottom the *lower* temperature field, and between the two the *stationary* temperature field. These fields are suggested by the relative position of the mercury in the thermometer, which is higher with higher temperature, etc.

One side or edge of the flag is the *local* rain or snow field; the other (indicated by the black stripe *b*) is the *general* rain or snow field, and between the two the *fair* or *clear* weather field.

Fig. 1.

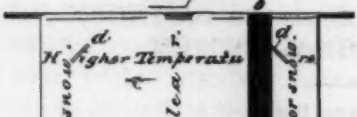


Fig. 2.

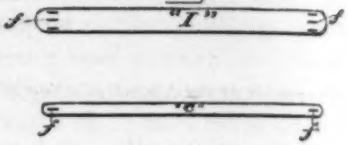


Fig. 4.

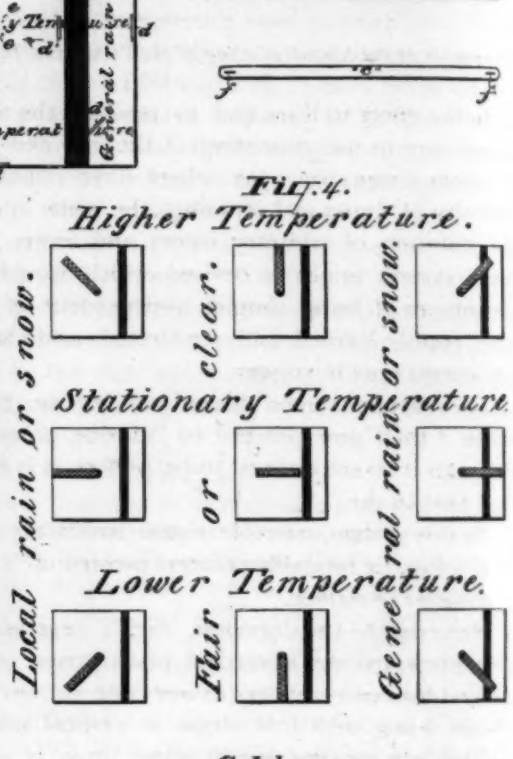


Fig. 5.

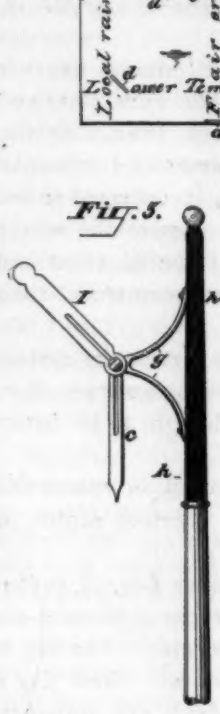


Fig. 5.

Fig. 6.

Proposed System of Weather Signals. (Pusey.)

All that is essential to be learned is the locations of these three temperature and three weather fields, which may be quickly and permanently done.

To indicate the particular signals required—both temperature and weather being indicated at the same time—I employ two bands, *Fig. 2*, of silk or bunting, one of which, *I*, is broad and is termed the "index," and whose function is to indicate the immediate probabilities; and the other, *c*, relatively narrow and termed the "change" or follower band, whose function is to indicate the weather probabilities following those indicated by the index band. The obvious object of this marked difference in the widths of these bands is to enable the one to be readily distinguished from the other. Their particular color or colors is unimportant, so that they be in strong contrast to that of the flag. Red for the index and blue for the change are preferred.

The flag is provided with button-hole slits *d*, equidistant from the centre, with the single exception of two slits (marked *d'*), a line connecting which slits traverses the stationary temperature and fair or clear weather fields.

At the centre of the flag, on both sides, are buttons *e*, for attaching the ends of the two bands, *I* and *c*, which are provided with button-holes *f*, at each end.

The bands are passed through one of slits *d*, according to the signal to be displayed, and the ends respectively are buttoned on both sides of the flag.

For the stationary temperature, clear or fair weather signal, the band or bands pass through the slits *d'*, so that the band will be in the two fields at the same time.

When a large flag is used, the bands may be further kept in place by means of light transverse straps at suitable intervals apart, the bands being passed under said straps.

When it is not desirable to use a flag, a device similar to that shown in *Fig. 3* may be employed. This consists of a kind of "semaphore," composed of bands or pointers, *I* and *c*, corresponding to the index and change bands for the flag.

The pointers swing from a pivot *x* at the junction of the ends of a bracket *g* that is fixed to and some distance below the top of a pole *h*. The former may be brought to any required position and there held by means of a thumb screw or other device. The

upper portion of the pole takes the place of the general rain or snow bar *b* of the flag.

The pointers are provided with longitudinal slots *s*, so as to allow them to be shifted towards the pivot, in order to make the stationary temperature clear or fair weather signal.

In order that the signals may be seen from any direction, there may be two sets of pointers connected with the pole in planes at right angles to each other.

Frequently, and in fact generally, the change signals are not used, in which case the narrow or change pointer may be turned back of the broad one and thereby be concealed from view. The pointers are removed for the cold-wave signal, and the flag is left bare for the same signal.

The diagrams, *Fig. 4*, show all the various signals. These correspond with those with which the general public is familiar. Cautionary or other signals may be made, if desired, by adopting arbitrary or, perhaps, suggestive shapes or colors for the pointers or bands.

To illustrate the difference between this system and the one now in use, the signal "higher temperature, local rain or snow," at the top of *Fig. 4*, on the left side, is made in the latter system by means of a flag with a red sun and one with a blue star.

The signal, *Fig. 5*, "higher temperature, general rain or snow, followed by lower temperature, fair or clear weather," is indicated in the present system by four flags in succession, to wit, a red ball, a blue ball, a red crescent and a blue crescent.

The signal, *Fig. 6*, "lower temperature, fair or clear weather, followed by higher temperature, general rain or snow," is indicated in the latter system by a red crescent, a blue crescent, a red ball and a blue ball.

It will be observed that the broad, or "index," band or pointer is always read first.

It may also be remarked that the signals in the proposed system form a straight line diagram; that is to say, the pointers or bands with the black stripe, or general rain bar. Thus a person glancing at the flag, or semaphore, will have the particular signal diagram impressed upon his mind, and will be able to carry it in memory for the day; whilst it is extremely difficult

to recollect the suns, stars and crescents, and their colors and order of succession, when several signals are displayed.

The salient advantages of the proposed system may be summed up as follows:

(1.) It is simple and suggestive, and readily learned and fixed in the mind, because of a certain easy association of ideas.

(2.) There is no confusion of colors and forms.

(3.) The signals being indicated by *direction*, they may be distinguished at long distances, far beyond those at which the *colors* of the suns, stars, etc., of the present system and their *forms* can be made out, unless of comparatively large dimensions.

This is especially the case with the semaphore construction, as the direction of the bands, or pointers, can be seen with the naked eye a distance of several miles.

(4.) It is much more economical, the cost of the one flag with bands, or the semaphore, being but a fraction of that of the flags required in the system now used.

HERSCHEL vs. JEVONS et al.

By Pliny Earle Chase, LL. D.

In the Journal of the Franklin Institute, for January, 1885, (p. 39), I pointed out "An Error by Maxwell," arising from a simple transposition of figures, a mistake with which all book-keepers are familiar. The error has led many recent writers, in popular text books and scientific journals, to assign to the luminiferous æther a density seventy-five per cent. greater than is justified by Maxwell's hypothesis.

An error of much greater importance has arisen from a misinterpretation of some passages in Herschel's "Lectures on Light." Jevons says (*Principles of Science*, ii, 145), "Sir John Herschel has calculated the amount of force which may be supposed, according to the undulatory theory of light, to be exerted at each point of space, and finds it to be 1,148,000,000,000 times the elastic force of ordinary air at the earth's surface, so that the pressure of the æther upon a square inch of surface must be about 17,000,000,000,000, or seventeen billions of pounds; yet we live and move, without appreciable resistance, through this medium

indefinitely harder and more elastic than adamant. All our ordinary notions must be laid aside in contemplating such an hypothesis; yet they are no more than the observed phenomena of light and heat force us to accept."

Fiske (*The Unseen World*, p. 20,) and Prof. De Volson Wood (*P. Mag.* [5] 20, p. 390,) write under the same misapprehension, overlooking the precaution which Herschel had taken to define his hypothesis, "that an amount of our ethereal medium equal *in quantity of matter* to that which is contained in a cubic inch of air [which *weighs* about one-third of a grain], were enclosed in a cube of an inch in the side," by italicizing the words which show that he was considering the *ratio* of elasticity to density, and not the simple elasticity.

Maxwell (*Enc. Britan.*, 9th Eng. edition, Art. "Ether") gives for the density of air at an infinite distance from the earth, 3×10^{327} less than his estimated density of æther. Applying the corrections which are required by his transposition, and interpreting his meaning as Jevons and many others have interpreted Herschel's, we should infer an æthereal pressure of more than 10^{324} tons per square inch, instead of $\frac{1}{6,820}$ of an ounce, which is the value legitimately deducible from Herschel's hypothesis. The weight of the cubic inch of æther would be only $\frac{1}{2,467,000,000,000,000,000,000,000}$ of an ounce, according to the same hypothesis.

Prof. Wood's mistake is the more remarkable from the fact that he proceeds precisely according to Herschel's methods, and obtains results which are substantially the same as Herschel's, although he supposes them to be new.

INSECT VISION.—F. Plateau has published a preliminary notice of some investigations in regard to insect vision. He refers to various hypotheses of Müller, Exner, Nuel and Carrière, and after recounting his own experiments he deduces the following provisional conclusions: (1.) Diurnal insects need a strong light, and are unable to direct their flight in a semi-obscurity. (2.) The simple eyes of diurnal insects, which are provided with compound eyes, are of so little use that they may be rightly regarded as rudimentary organs. (3.) Insects with compound eyes take no account of the differences of form between two illuminated openings, and are easily deceived, either by excess of luminous intensity or by apparent excess of surface. In other words, they either do not distinguish the form of objects at all, or they distinguish it very imperfectly. In these experiments, the insects were placed in such conditions that they could be guided neither by color nor by smell, but were obliged to depend upon sight.—*Bul. de l'Acad. de Belg., No. 8, 1885.*

BAIRD'S ANNUNCIATOR.

FRANKLIN INSTITUTE, PHILADELPHIA, Pa.

THE COMMITTEE ON PUBLICATIONS:

Gentlemen:—In the JOURNAL for January, of this year, I find an interesting description of a "Steam Vessel Indicator," page 82. The inclosed report, I think, would supplement that item. The report in question was prepared for the use of the engineers using the machines.

The objects of the "Steam Vessel Indicator" and my Annunciator are not identical, in that the former indicates the position of the reversing gear and the throttle, while the latter indicates whether the engine is revolving, and in which direction, and also its approximate velocity.

The "Steam Vessel Indicator" might indicate the link in ahead motion and throttle wide open, but if the engineer has his cut-off far on, or his valves lapped, the engine will not move, though the indicator may lead pilot to believe it is going. As the annunciator is already adopted by the Navy, its publication in the JOURNAL would not be out of place, considering the number of Navy engineers who read the JOURNAL.

With great respect,

Your servant,

G. W. BAIRD,

Nassau, N. P., February, 1886. *P. A. Engineer, U. S. N.*

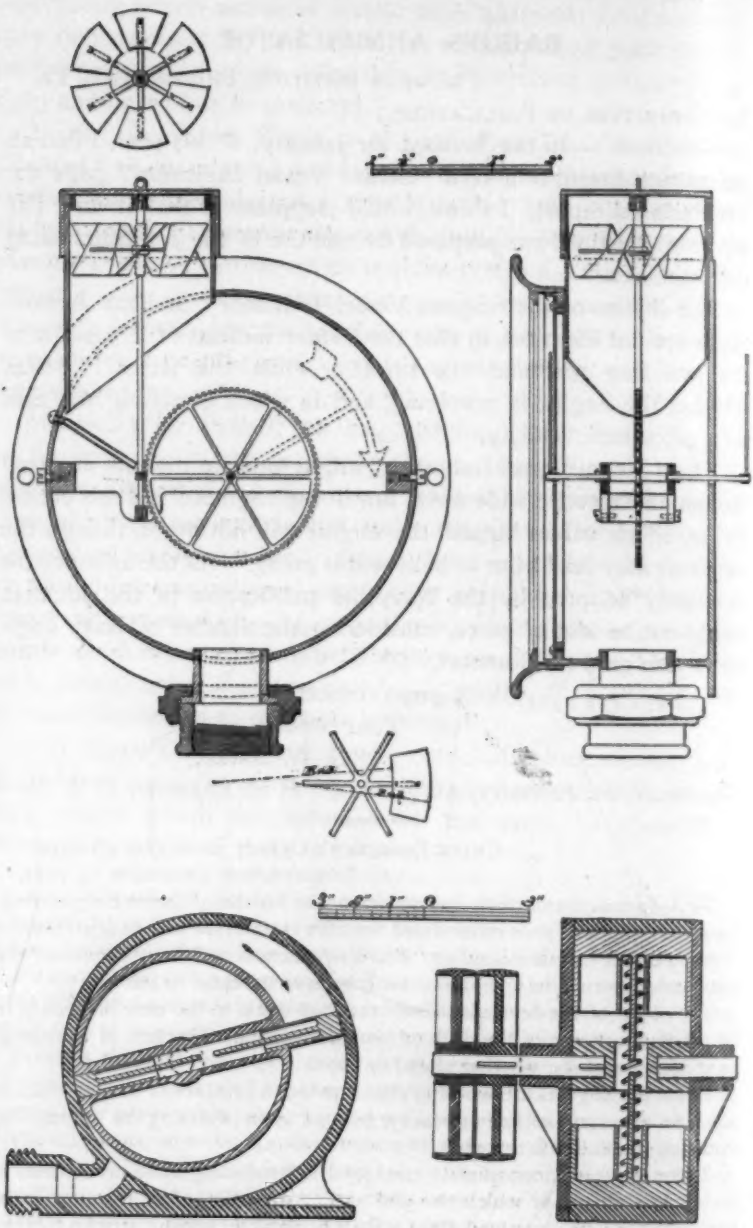
CHIEF ENGINEER'S OFFICE, U. S. NAVY YARD,
WASHINGTON, December 19, 1885.

Sir:—In compliance with instructions of the Bureau of Steam Engineering, dated the 15th, and your order dated the 16th instant, the Board appointed to examine the device described as "Baird's Annunciator," have examined the apparatus, observed its operation, and beg leave to report as follows:

The object of the device is to indicate upon deck, to the easy inspection of the officer in charge of the deck or his assistants, the direction of the movement of the engines, whether ahead or aback.

While the engines are working ahead an index revolves in the direction in which an arrow, on its free extremity, points; upon reversing the engines the motion of the index is reversed.

The mechanism immediately employed in producing these movements is enclosed in a case, of which the dial over which the index revolves is the face. The index is mounted upon a shaft or spindle, which carries a toothed wheel.



Baird's Annunciator.

The wheel and spindle are turned by the revolutions of a second spindle placed at right angles with the first, carrying a worm or endless screw, the threads of which mesh with the teeth of the wheel. The second spindle carries also a series of fans, arranged like the blades of a screw propeller, or like the vanes of the common anemometer.

By means of an air current, which flows in one direction when the ship's engines are going ahead, and in the opposite direction when they are backing, the fans and their spindle are rapidly revolved, and the proper motion transmitted through the spiral gearing to the index. The movement of the index is moderate in speed, but the speed is variable with the speed of the engine, and incidentally affords a means of estimating, by the eye, the speed as well as the direction of the movement of the engines and the ship.

The air current is derived from a small rotary blower, placed near the engine shaft, and turned by it through the operation of belts. When turned in one direction, the blower draws the air from the vanes of the annunciator through a pipe, in one enlarged extremity of which, forming a mouth, the vanes revolve. When turned in the opposite direction, the air is driven through the connecting pipe to the vanes, and the direction of the movement of the latter, upon the instant, reversed.

It is a very great advantage to the person manœuvering the ship, to know, without the delay attending inquiry, or observation of the movement of the ship herself, exactly what the latter is to be. Should mistake be made, it will be apparent before it is too late to correct it.

The apparatus is simple and elegant, the power consumed by it is inconsiderable, and it is not at all likely to get out of order.

Its first cost needs never to be great, and the cost of maintenance trifling. Drawings of it are hereto appended.

The Board recommends it for purchase and use for purposes under cognizance of the Bureau of Steam Engineering.

We are, Sir, very respectfully,

Your obd't serv'ts,

CHARLES H. BAKER,
Chief Engineer, U. S. N.

R. D. TAYLOR,
P. Asst. Engineer, U. S. N.

R. R. LEITCH,
P. Asst. Engineer, U. S. N.

COMMODORE W. W. QUEEN, U. S. N.,
Commandant.

RAPID TRANSIT AND ELEVATED RAILWAYS.

COMMITTEE ON PUBLICATIONS:

Gentlemen:—I send the following, to print as a note in the JOURNAL, if you see fit.

NOTE.—The engine for the new Meigs elevated railway system

was steamed up and run for the first time January 3, 1886, the driving wheels being prevented from touching the track. The following day, the locomotive was run upon the track.

On Friday, April 16, 1886, the first train, consisting of engine, tender and passenger car, the latter over fifty feet in length,* was made up and started at 3.15 P. M., going around a semi-circular curve of 50 feet radius, built upon an ascending grade of 120 feet to the mile. On Monday, April 19th, the Legislative Joint Committee (Mass.) on Street Railways, visited the works, and the engine mounted the 345 feet grade without the slightest difficulty.

A loosely-fastened rail was ripped off without any effect to the train. The experiment was perfectly successful, and all present were much pleased with the exhibition and listened with the closest attention to Capt. Meigs' explanations.

It need hardly be said that these are facts never before accomplished in railroading, and the new region of possibilities thus opened must produce results of a practical value beyond what can be, at this time, foreseen. In a few days the rolling stock will become sufficiently "limbered up" to make the trips around Capt. Meigs's difficult piece of track with ease, the entire safety from derailment having been already fully demonstrated.

F. E. GALLOUPE.

Boston, April 24, 1886.

ELECTRIC LIGHT FOR LABORATORY INVESTIGATION.—M. de Lacaze-Duthiers uses, in his Sorbonne laboratory and in his zoölogical stations at Roscoff and Banyuls, an electric lamp constructed by Trouvé, which would also be useful in much chemical, botanical and mineralogical work. It is composed of a cylindrical glass vessel, beneath which is a mirror of silvered glass. There is a silvered parabolic covering, in the centre of which is suspended an incandescent lamp. The vessel is filled with sea-water containing corals, polyps, sea worms and other objects which can be examined by the aid of magnifying glasses, the whole mass being thoroughly illuminated, as in the brilliant experiment of the illuminated fountain. The apparatus can be readily modified for the study of fermentation, and for dissecting, with great ease, nervous filaments of the greatest delicacy, which are hardly visible in the broad light of day. The generator of electricity is Jamin's universal automatic battery, weighing less than three kilogrammes.—*Comptes Rendus, Aug. 3, 1885.*

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* The full description was published in the JOURNAL, January–April, 1886.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE BILGRAM BEVEL GEAR CUTTER.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, April 29, 1886.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

HUGO BILGRAM'S BEVEL GEAR CUTTER,

Report: That the description and the copy of Patent No. 294,844, appended to these papers, contain a full and clear explanation of the construction and operation of the Bevel Gear Cutter; and that the extract from the JOURNAL OF THE FRANKLIN INSTITUTE of January, 1882, also appended, explains the theory upon which the machine is based.

After a critical examination of the machine and its product, and a careful study of the theoretical demonstration, we consider this a remarkable example of original invention. It is original in introducing the "path of contact," instead of the rolling curves, as a base for the theory of gear wheels; in introducing a new odontograph, in which a portion of a rack is used to delineate or envelop on a wheel a tooth form, which will properly gear with this rack or with any other wheel whose teeth have been delineated by the same rack; and in designing and constructing a machine for cutting theoretically perfect teeth in bevel gears, the adjustment, manipulation and operation of the machine being all that could be desired and the gears cut by it being superior to anything of their kind, known to your Sub-Committee.

We therefore recommend the award of the ELLIOT CRESSON GOLD MEDAL to HUGO BILGRAM for his Bevel Gear Cutter.

WM. H. THORNE, *Chairman.*
WILFRED LEWIS,
CARL BARTH,
LUTHER L. CHENEY,
OTTO C. WOLF,
C. CHABOT,
THOS. SHAW, M. E.

Adopted June 8, 1886.

H. R. HEYL, *Chairman.*

APPENDIX.

(Accompanying Committee's Report.)

In a paper read before the FRANKLIN INSTITUTE, November 16, 1881, entitled "A New Odontograph" (FRANKL. INST. JOURN., Jan., 1882), the author* remarks that "the principle of this odontograph may even be used in the construction of a gear-cutting machine, to give theoretically correct shapes. Suppose a shaping machine, provided with a tool of the shape of a rack tooth, would, by the cross-feed, produce a simultaneous rotation of the wheel to be cut, or rather corrected, say by means of a thin steel band running over a cylinder of the diameter of the pitch-circle of the wheel. This operation is identical with the above-described application of the odontograph. The same tool will give the proper form to all wheels, large or small, of the same set. This plan would even be applicable to the cutting of theoretically correct bevel wheels, by cutting only one side of a tooth at one time, especially if the involute form of teeth is adopted. For practical reasons, however, it is doubtful whether such machines would be commercially successful."

This suggestion has since been carried out by the construction of machines for cutting bevel gears, and the excellence of the work produced confirms the correctness of the theory stated, at the same time dispelling the doubts of commercial success.

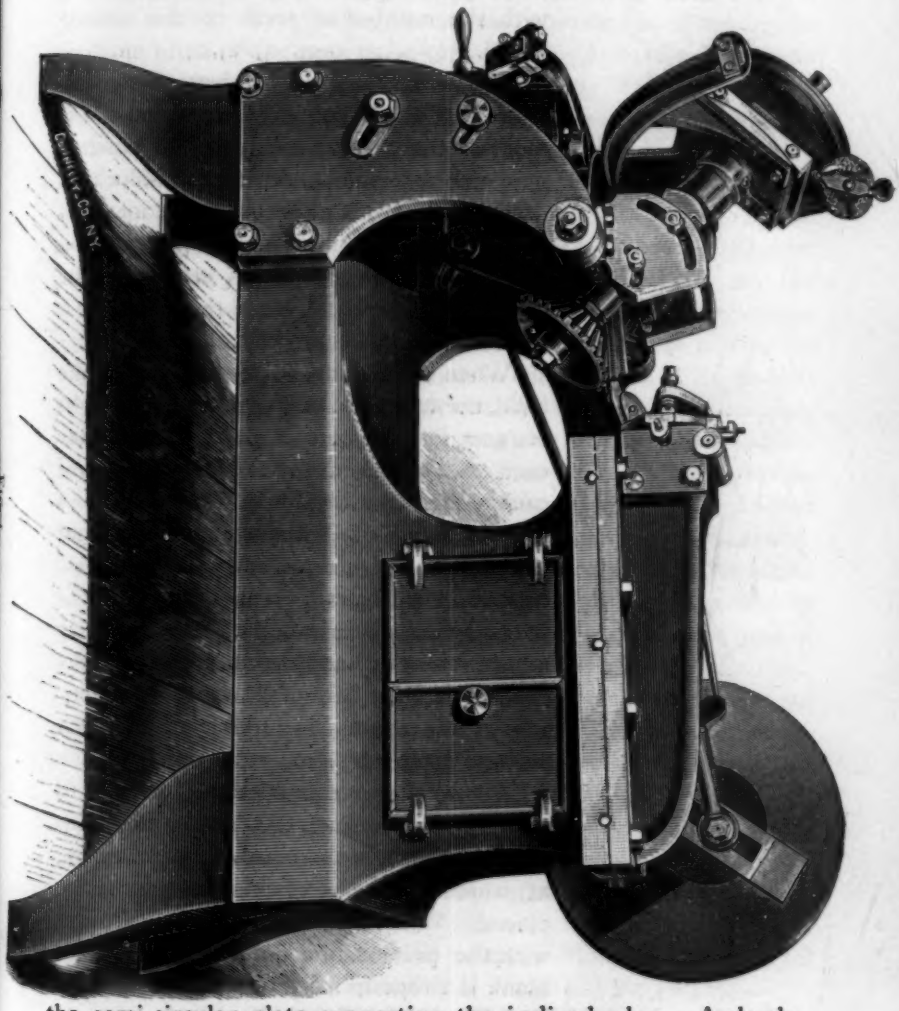
The machine, as represented in the accompanying cut, consists of a mechanism for imparting to the blank to be cut, the necessary rolling motion, and of a shaper-like tool-moving device.

The compound movement of a cone, rolling on a plane surface, can be resolved into two simple movements. The first is an imitation by the axis, of the movement of a conical pendulum, and the second is a rotation of the cone on its axis. These movements are accomplished as follows: The arbor, carrying the blank to be cut, is secured in an inclined position to a semi-circular horizontal plate, which can be oscillated on a vertical axis passing through the apex of the blank. To complete the rolling action, a portion of a cone—coinciding with the pitch cone of the blank—is attached to the arbor and held by two flexible steel bands, stretched in opposite directions, which confine the cone to a purely rolling motion as the semi-circular plate is moved, for the purpose of imparting to the arbor the necessary swinging motion. The rolling cone, which is

* By Hugo Bilgram, M. E.

held by the flexible bands, is placed on the side of the apex opposite that to which the blank is secured, to avoid interference with the tool.

The feed mechanism imparts a slow intermittent movement to



the semi-circular plate supporting the inclined arbor. A slowly progressing rolling of the blank ensues while the reciprocating tool cuts its way through the metal. The reversal or disengagement of the feed is in the power of the operator.

The arbor carrying the blank can be rotated independent of the

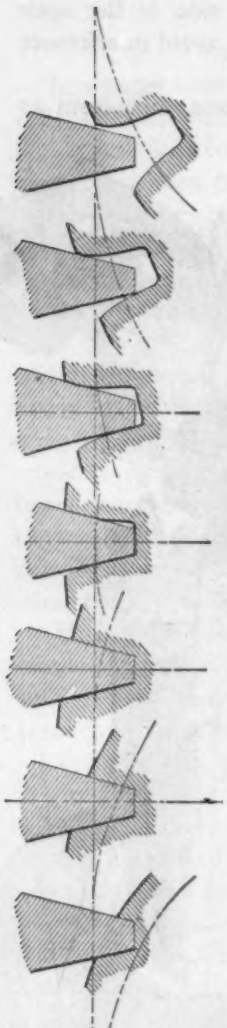


FIG. 2.

rolling cone by means of a worm wheel, worm and index plate, which enables the blank to be presented to the cutting device at properly spaced divisions corresponding with the number of teeth of the desired wheel.

The accuracy of the product of the machine depends largely on the proper adjustment of the cutting tool, to effect which a gauge is provided. A distance block is used between this gauge and the tool; this mode admits of a high degree of accuracy, since variations of distances can readily be detected by the touch when the eye ceases to discern.

When a wheel is to be cut out of the solid, the tool is at first adjusted at a slight distance from its correct position, and after each cut the feed motion of the evolver causes the blank to slowly roll, and allows the tool to cut out the stock in the manner shown in the diagram. All spaces are now treated in the same manner by using the index device, whereupon the tool is properly adjusted for one and then for the other side, each adjustment being followed by a repetition of the process in order to finish both sides of the teeth.

A special device enables the operator to gauge the distance of the ends of the teeth from the centre of the revolving mechanism, at which the apex of the blank must be placed. When this measurement coincides with the previously computed distance, the blank is properly located.

The inclination of the arbor, which holds the blank, is made adjustable, so as to adapt it to the angle of the desired gear. This adjustment must be exactly concentric with the apex of the blank. The rolling cone is made detachable, in order that it may be

replaced by such cones as correspond with the angle of the blank to be cut.

The tool consists of a triangular bar of hardened steel, forming at the point an angle of 30°, 15° on each side, and held by a special holder. By grinding, it can be more or less truncated to suit the pitch of the gear to be cut. By this form of tool a much higher degree of accuracy is attainable than with tools having curved faces made to a templet. The proper up and down and side-way adjustment is effected by two slides working at right angles, and operated by screws. The clamp, which fastens the tool-holder, is so constructed that it also clamps these said slides to the apron, securing the necessary stability. The apron is fitted with great care; the box in which the apron works is made in parts, and the faces are turned true with the pin-holes, in order to get these faces exactly at right angles with the pin. The latter is fast in the apron, and revolves in the two sides, in which it has taper fits that the wear may be taken up. A device for lifting the apron during the return stroke prevents the dragging of the tool. The oscillating movement of the connecting-rod is employed for this purpose, by having a bar hinged at one end to a clamp, which can be shifted on the connecting-rod while the other end impinges on the apron. By a lifting of the crank end of the connecting-rod, the loose end of this bar is pushed forward and the apron is lifted. It is easy to so adjust the clamp that this lifting action will occupy the time of the return stroke.

The tool-bar is moved by a Whitworth quick-return motion, which is attached directly to the belt pulley. A double counter-shaft, connected by cone pulleys, is employed to change the speed if a shorter or longer stroke is desired.

Gears cut on this machine are practically as nearly perfect as it is possible to produce plane surfaces on a planer. For this reason a careful preparation of the blanks is essential.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE PRATT & WHITNEY SYSTEM OF INTERCHANGEABLE CUT GEARS.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, May 5, 1886.

The Sub-Committee of the Committee on Science and the Arts,

constituted by the FRANKLIN INSTITUTE, of the State of Pennsylvania, to which was referred for examination

THE PRATT & WHITNEY SYSTEM OF INTERCHANGEABLE CUT GEARS

Report: That they have carefully examined the matter submitted to them.

The application relates to a system for producing epicycloidal spur gears of a very high degree of perfection.

The first process in the system consists in procuring accurate templets for making the cutters. These templets are produced on a machine in which a rotary cutter is guided in epicycloidal and hypocycloidal paths by the actual rolling of describing circles on a circle representing the pitch line of the wheel. The difficulty of passing the cutter from the epicycloidal path of the face of the tooth-templet to the hypocycloidal path of the flank is met by a most ingenious device deserving the highest commendation. The machine is minutely described in the pamphlet accompanying this report. On this machine a complete set of templets of only one pitch can be produced.

The second machine is designed to make the properly formed rotary cutters. The templets are used to guide the tool, and in this manner the formed cutters obtain the exact shape by positive machine movements without the aid of skilled labor or hand-work. By the application of the pantographic principle, cutters of any pitch can be made from the one set of templets prepared on the first machine. For a detailed description of this machine, we again refer to the pamphlet accompanying this report.

The specimen gear wheels and rack which have been furnished, exhibiting the work performed by such cutters, confirm the conclusion that a high degree of accuracy can be attained by this process.

Your Sub-Committee have concluded to recommend the award of the ELLIOT CRESSON GOLD MEDAL, for the conception and putting into practice the system of producing cutters, and the SCOTT LEGACY, MEDAL and PREMIUM, for the ingenuity displayed in the detailed construction of the machine.

Respectfully submitted,

HUGO BILGRAM, *Chairman.*
C. CHABOT,
LUTHER L. CHENEY.

Adopted June 8, 1856. H. R. HEYL, *Chairman.*

THE "NOVELTIES" EXHIBITION OF THE FRANKLIN INSTITUTE, 1886.

ABSTRACTS OF REPORTS OF THE JUDGES.

(*Continued from page 80.*)

GROUP 5*a* 5*b*.—COAL, MINERALS AND METALLURGY, METALLURGICAL PROCESSES AND PRODUCTS.

Judges:—Samuel R. Marshall, *Chm.*; W. H. Blake, M. D., D. E. Rice, M. D.

C. H. DELAMATER, NEW YORK.

The Waring Centrifugal Pulverator.—For the pulverizing of ores, phosphates, rock, cement, etc. The judges consider it well calculated to sustain the maker's claims and think it the best and most desirable machine now in use in respect to efficiency, economy of labor and power with the minimum of wear. (*A Silver Medal.*)

GROUP 6.—DISTILLATION, BREWING, REFRIGERATION AND FERMENTATION APPLIANCES AND PRODUCTS.

Judges:—Dr. W. H. Greene, *Chm.*; W. W. Griscom, F. A. Genth, Jr., S. Lloyd Wiegand, J. W. Grant.

The judges have examined "The De La Vergne Refrigerating Machine Company's exhibit," "The Hutchinson Ice Machine," exhibited by the I. P. Morris Co. "The Universal Dry Air Refrigerator," exhibited by the Dickson Manufacturing Company, of Scranton. "The Yaryan Vacuum Distillation Apparatus."

The refrigerating machine of the DE LA VERGNE COMPANY and the HUTCHINSON ICE MACHINE are both in successful operation at the exhibition, and we are unable to make any discrimination as to the awards to which they are entitled. In each machine the cold is produced by the expansion of anhydrous ammonia, which has been previously liquefied by compression and cooling. For the lubrication of the ammonia compressor, the De La Vergne machine employs so large a quantity of oil as to constitute a liquid piston. The Hutchinson machine has a solid piston while sufficient lubrication is not neglected.

The Universal dry air refrigerator is especially adapted for

maintaining a circulation of cold air in chambers in which perishable food is preserved. The air is compressed to about one-fourth its volume, and after cooling is allowed to expand under the normal atmospheric pressure; thus cooled, it passes into the chambers to be refrigerated.

The construction and operation of each of these refrigerating machines is such that an exact comparison of their merits and economies can only be definitely ascertained by a test, for which purpose we recommend that they be referred to the Committee on Science and the Arts, such test being impracticable in the limited time and with the facilities of the exhibition. We believe their operation warrants this recommendation.

(*Each a Silver Medal and reference to the Committee on Science and the Arts.*)

The Yaryan Vacuum Distillation apparatus accomplishes concentration of liquids at low temperatures as in the ordinary vacuum pans, but the evaporation takes place continuously, the liquid flowing through a series of pipes which are jacketed by other pipes carrying steam. The flow of liquid is maintained constant by an automatic pump.

(*A Silver Medal and reference to the Committee on Science and the Arts.*)

GROUP 7.—DRUGS, CHEMICALS, DYE STUFFS, PAINTS, SOAP AND PERFUMERY AND APPLIANCES THEREFOR, AND PHARMACEUTICAL APPARATUS.

Judges:—Thos. S. Wiegand, *Chm.;* F. A. Genth, Jr., D. E. Rice, M. D., H. C. Archibald, M. D., H. Pemberton, S. Lloyd Wiegand.

The judges of group 7, charged with the examination of drugs, chemicals, paints, pharmaceutical apparatus, perfumery, etc., respectfully report that they have examined the articles exhibited, and make the following recommendations:

THE KALION CHEMICAL COMPANY, PHILADELPHIA.

For their exhibit of bichromate of potassium, vanadate of ammonium (meta-vanadate of ammonium), chloride of potassium, etc.

The first two of these are of unusual excellence and make a very fine exhibit. (*A Silver Medal.*)

JAS. M'NAB, PHILADELPHIA.

(U. S. Chemical Company assignees.)

Exhibits a model for the manufacture of sulphuric acid. The patentee states that by means of a supplementary tower, etc., as described, he can remedy in a short time the "sickness" or "paleness" of the acid, which is likely to occur in the last chambers and reduce the consumption of nitrate of soda.

The importance of the sulphuric acid industry induces the judges to call the attention of the Committee on Science and the Arts to this model for a more thorough examination than can be made by this committee.

(*A Silver Medal and reference to the Committee on Science and the Arts.*)

NATHAN BASSETT, OF PHILADELPHIA.

Exhibits a mixer for dry powders, such as paint, flour, etc. It is constructed upon correct principles, and will be of unquestionable advantage. (*Honorable Mention.*)

BARROWS, SAVERY & CO., LIMITED, PHILADELPHIA.

Steam Jacketed Kettle.—These are made of cast iron extremely thin and stiffened by ribs cast with the kettle upon the outer surface and extending radially from the centre of the bottom to the flange, which unites the kettle to the enclosing jacket, which is of similar form.

The large surface both of the ribs and the entire surface of the inner kettle permits rapid absorption of heat from the steam, and the condensed water is guided by the ribs in its descent, so as to keep the surface of the kettle in most effective condition for heating.

By the system of ribbed braces strong kettles of extremely thin metal are made practicable, which heat and cook expeditiously, and are durably enamelled so as to have all the properties of cleanliness and resistance to corrosion found in the Berlin porcelain wares, attended with an increase in capacity impracticable in such ware, and at a cost far below that of copper vessels capable of application to the same uses.

The judges are of the opinion that these vessels are an important addition to laboratory and large culinary operations.

(*A Silver Medal.*)

GROUP 8.—ELECTRIC LIGHTING, MOTORS, DYNAMOS, GENERATORS AND BATTERIES.

Judges:—E. Alex. Scott, *Chm.*, J. Sellers Bancroft, A. B. Wyckoff, Horace W. Sellers, Oberlin Smith, Henry A. Rowan.

Of the articles at the Exhibition properly referable to this group, only one was entered for competition—the Edgerton motor, exhibited by

THE EDGERTON MOTOR MANUFACTURING COMPANY, OF PHILADELPHIA.

This company exhibited electric motors of several sizes, from one-twelfth to six horse-power capacity, quite simple in construction. The armature is made in one casting cylindrical in form, split longitudinally into three parts, each of which is supported on the hub or axle by a wide spoke or flange. Upon each of the three flanges is wound a coil of wire, varying in size according to the work required; these coils are connected together at one end of the armature by means of a metal ring, to which an end of each is attached, and the three opposite ends are connected with the commutator. The special advantage claimed for the division into three portions is that there is no dead point in the revolution of the armature, and the form of connection described permits such an adjustment of the coils that the same electrical result will be produced on each of the coils in turn as it reaches the proper point.

The weight of metal in the armature is placed as near the surface of the cylinder as is consistent with strength, so as to bring it near the field. The ends of the cylinder project as far beyond the coils as the thickness of the layers of wire on the coils. The wire is sheltered by the iron and cannot be injured by abrasion on the field. The field is a cylinder, split in half longitudinally, and closely fitting the armature, so that a piece of writing paper could hardly be inserted between them; both the armature and field are turned in a lathe. The winding of the field is upon a series of spools attached to the back of the two parts of the cylinder. The whole is enclosed in an iron shell, to which it is screwed, which supports the bearings and the armature, and forms the yoke of the magnet.

The inventor claims simplicity of construction and durability; that the armature can be run at any speed without displacing the

coils, or permitting them to touch the field; that the metal of the armature is brought nearer to the field; that the counter electromotive force in the wire of the armature is much diminished on account of the wire being further removed from the field.

The judges believe that the claims of the inventor, as above stated, are well sustained by the facts, and that a greater durability and efficiency are thus secured. (*A Silver Medal.*)

GROUP 9.—EDUCATIONAL APPLIANCES.

Judges.—Edward Lewis, *Chm.;* Jas. S. Whitney, Lewis M. Haupt.

GEO. J. BAIR, PHILADELPHIA.

The Stenograph, a Machine for Writing Shorthand.—In this machine, the letters are formed by the operation of only five keys. Each key makes a dash in a certain position on the paper, and when two or more keys are struck at once, a great variety of combinations can be made to represent different letters or sounds. It appears to be capable of rapid operation, and for its novelty and usefulness the judges recommend— (*A Bronze Medal.*)

WM. H. TRAVIS, PHILADELPHIA.

Caligraph Type-Writer.—This machine has a double set of keys for large and small type, and every key produces but one letter—the one shown on its face. By this means, shifting keys are avoided, and a saving of time is claimed.

All joints or bearings are provided with adjustable screws, so that lost motion from wear can be taken up as it occurs. A novel feature of the machine is its flat surface roll, which always presents a flat surface to the type, thus giving a clear and full impression of every letter. (*A Bronze Medal.*)

GROUP 10*a*.—FURNITURE.

Judges:—H. R. Heyl, *Chm.;* J. J. Weaver, Samuel Sartain, Isaac Norris, M. D., Fred. Graff.

CLARK BROS. & CO., PHILADELPHIA.

"Everett" Improved Folding or Wardrobe Bedsteads.—These contain recent improvements upon those previously made under the same inventor's patents. They are very well balanced, easily operated, well ventilated, and in all respects excellent beds, and handsome pieces of furniture. (*A Silver Medal.*)

HALE & KILBURN MANUFACTURING COMPANY, PHILADELPHIA.

A variety of Folding Bedsteads of the Wardrobe and Telescopic Patterns, which are commendable as articles of convenience, practical utility, and as handsome and well made pieces of furniture. A portable reservoir wash-stand, disguised as a writing-desk, shows an ingenuity of combination and beauty of form that renders it very complete, convenient and desirable.

Their display of other furniture and handsome chamber suites is deserving of high commendation for artistic design and superior workmanship. (*A Silver Medal.*)

GATES MANUFACTURING COMPANY, PHILADELPHIA.

A Rotating, Adjustable, Sliding- and Tilting-Top Folding Table.—It is well made, ingeniously designed and very substantial, as well as ornamental. (*A Silver Medal.*)

HENRY GIESE, PHILADELPHIA.

Barber's Chair.—A device applicable to barber's chair, for the elevation and angular adjustment of the back. It is mechanically well designed for the purpose. (*Certificate of Honorable Mention.*)

JOHN RUCH & SONS, PHILADELPHIA.

Specimens of Upholstery, which are excellent, and *Prepared Moth-proof Hair.*

The judges are satisfied as to the reliability of the process as an effectual moth-proofing, but the durability and continued elasticity of the hair so treated can only be determined by a long trial in use.

The exhibit is worthy of commendation for good workmanship, and apparently good results in the direction of preserving upholstery from the ravages of moths. (*A Bronze Medal.*)

SHUPE & NOBLE FURNITURE COMPANY, PHILADELPHIA.

A variety of useful pieces of furniture, notably their "Climax" Folding Bed, which in some of its forms makes an exceedingly light and portable bedstead. It is capable of being advantageously combined with a book-case and writing-desk in a very practical manner, and in some of its forms is very cheap, and a desirable article of furniture. (*A Bronze Medal.*)

HAYNES, SPENCER & CO., RICHMOND, IND.

Several Forms of the *Wootten Writing-desks*, which have an

established and excellent reputation. They are beautiful articles of furniture, well made, very compact, and convenient, and moderate in price. (*A Bronze Medal.*)

LEWIS M. HAUPT, PHILADELPHIA.

Exhibits an arrangement of shelves, closets, drawers, pigeon-holes, adapted for holding books, papers, maps and drawings in a convenient and readily accessible form. The plan is commended for its compactness, convenience and portability.

HARWOOD MANUFACTURING COMPANY, BOSTON, MASS.

Fibre Chair Seatings.—These seats are made of a manilla board, pressed and finished in imitation of leather, and have a handsome appearance. They are claimed to be water-proof and durable and extensively used in the Eastern States.

(*A Certificate of Honorable Mention.*)

GROUP 10 *b* AND *c*.—CARPETS AND UPHOLSTERY AND INTERIOR HOUSE DECORATIONS.

Judges:—S. Lloyd Wiegand, *Chm.;* Coleman Sellers, Jr., Henry B. Riehlé, John A. Wiedersheim.

V. E. ARCHAMBAULT & SON, PHILADELPHIA.

Corticine, manufactured by the Corticine Floor Covering Company, of London, England.

This appears to be * * * an excellent quality of linoleum and as such deserving of commendation.

F. X. BRENNER, PHILADELPHIA.

Self-Tieing Awning.—Consists of a casing or covering containing a very conveniently arranged winding cylinder, bearing the awning and mechanism for turning the same, and also an automatic reel by means of which the awning is readily and securely fastened as closed or extended or in any intermediate position. This is ingenious and useful. (*A Certificate of Honorable Mention.*)

WM. L. WILSON & CO., LIMITED, PHILADELPHIA.

This exhibit embraces several mantels containing enamelled tiles artistically decorated and skilfully jointed together; also, hearths embracing enamelled tiles in mosaic work.

Also a panel illustrating the several species of decoration in encaustic tiles, enamelled tiles, mosaic designs and ceramic art work, embracing the several lines of work executed by this firm.

The enamelled tiles are of English manufacture, and the balance of the work American.

For skilful work and creditable designs— (*A Bronze Medal.*)

BRAINERD & ARMSTRONG, PHILADELPHIA.

Embroidery Silk upon Quills.—This is an article put up by the manufacturers in the form that is best adapted for use by the retail purchaser, and carries with it the label and reputation of the maker to the consumer, conditions which insure the best maintenance of quality.

Victoria Knitting Silk.—The dyes employed in this silk are more permanent than others, withstanding such tests as continuous boiling in water; for uniform excellence of quality both of silk and dye— (*A Silver Medal.*)

J. C. FINN & CO., PHILADELPHIA.

Wall Coverings of Lincrusta Walton, of great beauty of design and perfection of workmanship, manufactured by Fr. Beck & Co., of New York. For richness of design, skilful execution and tasteful display— (*A Silver Medal.*)

A. J. MALONE, PHILADELPHIA.

Excelsior Natural Wood Stains, for imitating hard and fancy woods. These produce excellent imitations, are of easy application and appear to be of good quality and durable.

(*A Certificate of Honorable Mention.*)

SHARPLESS & WATTS, PHILADELPHIA.

Ceramic and Roman Mosaics, of American manufacture, all of excellent quality and skilfully wrought into very rich and elegant designs in mantels, hearths, fire-boards, flues, baths, walls, etc.; also an extremely rich and elaborate exhibit of bronze mantel decorations of unusual excellence and beauty.

The entire exhibit displays skilful work and tasteful designs as well as excellent quality of material. (*A Silver Medal.*)

GROUP 10 *d.*—HATS AND WEARING APPAREL, UMBRELLAS, ETC.

Judges:—John A. Wiedersheim, *Chm.;* Wm. H. Hart, Jr., Wm. H. Thorne.

CHAMBERS & CO., PHILADELPHIA.

The Reliable Umbrella of these exhibitors is meritorious. The stretchers are adapted to prevent the ribs from sticking or catching, and to reduce the space into which the umbrella may be

folded. In opening the umbrella, when the tip cap or other fastening is removed, the ribs are thrown out and away from the stick by the action of the stretchers, thus providing an enlarged space whereby the hand may reach the runner in a most convenient manner without liability to be injured by the points of the ribs. (*A Bronze Medal.*)

JAMES BERNARD WILSON, PHILADELPHIA.

Improvements in Umbrellas.—In this umbrella, the use of the well-known spring catches and slotting of the stick are avoided, and, in lieu thereof, there are employed two catches and a pivoted latch lever. The lever is easily operated to release the runner, and prevents cutting of the thumb, as is usual where the latter presses the wire catches. The face of the lever is adapted to be used as a name-plate, and furnishes a neat finish to the runner.

(*A Bronze Medal.*)

NORCOM L. SEGUIN, PHILADELPHIA.

Improved Self-Closing Umbrellas.—The stick of the handle is connected with the upper catch, and a spring is so arranged that by a simple movement of a pin on the handle, the runner is released and the umbrella closes automatically. The frame is strengthened by scroll-shaped stretchers in such a manner that it is enabled to withstand any strain that may be imparted to it, due to the sudden closing of the umbrella. The judges consider this a useful and valuable improvement in umbrellas.

(*A Bronze Medal.*)

THOMAS R. EVANS, PHILADELPHIA.

Anatomical Boots, Gaiters and Shoes.—The top of the gaiter or shoe is detached in front from the vamp or foot-piece which allows the foot its natural movements. In the boot, an elastic cloth is placed in front, which allows it to be put on and taken off very easily. An accurate fitting of the boot to the ankle-joint is allowed, slipping at the heel prevented, and the ankle-joint retains its natural and unobstructed movements. From the practical demonstration by the exhibitor, the judges believe that the meritorious nature of the improvements warrant—

(*A Bronze Medal.*)

(*To be continued.*)

BOOK NOTICES.

DRAINAGE FOR HEALTH, OR EASY LESSONS IN SANITARY SCIENCE. By Joseph Wilson, M. D. Second Edition. Philadelphia: P. Blakiston, Son & Co.

The first chapter of this work is devoted to the subject of land drainage, and contains the following passage, which refers to one of the most important facts that science is called upon to consider. "In all parts of New England hundreds of people are dying of typhoid fever; a large tract of the city of Boston is now building on made-land nearly as flat as the prairie around Chicago, and in a few years it will probably have to be regulated and rebuilt to get rid of the pestilence. From Maine to Pennsylvania there are undrained fields nearly as bad. All over the country further south, but principally in the Mississippi Valley and in the flat country bordering the ocean, the undrained land is infectious with intermittent fever and other malarial pestilences to such an extent as to destroy many thousands of lives every year; so that in spite of constant immigration extensive tracks of country continue as sparsely populated as ever, with very unhealthy, very unhappy people. Some parts of this desert is the most fertile land in our country, and the most easily cultivated, but for the failure of health among those who undertake to occupy it."

The remedy for this is drainage, and the various methods are fully explained and illustrated by appropriate cuts.

The second chapter contains some brief but pointed remarks on the subject of house drainage, in reference to isolated houses. While the third chapter considers the subject of the drainage of cities, which includes the details of the so-called "modern conveniences," which it must be admitted, have, within the last few years, been brought to a perfection that leaves little to be desired in the way of improvement. Yet it is a lamentable fact that the water-carriage system, with all its advantages, involves the necessity of wasting valuable manure and polluting the rivers in a most disgusting and dangerous manner; for, as the writer points out, minute organisms may thus be introduced into the stomach, which may produce the most serious results. This statement is rendered very impressive by reference to the young of the tape-worm, which may penetrate to vital parts of the body and produce death.

We reviewed the first edition of this work in the February issue of the JOURNAL in the year 1881, and do not observe that anything of value has been added to this edition.

W. B. C.

CLASS BOOK OF GEOLOGY. By Archibald Geikie, LL.D., F.R.S., Director-General of the Geological Surveys of the United Kingdom, etc. London: MacMillan & Co. 1886.

This book, as stated in the preface, completes a series commenced while the author occupied the Chair of Geology in the University of Edinburgh, now filled by his brother. One of the best features of these books is that their author was sufficiently in earnest, in producing them, not to be turned from his purpose by his largely extended field of labor consequent upon

taking active charge of the Survey of the British Isles, relinquished by Ramsay. The present book is a small octavo of 478 pages, with an appendix of twenty pages and an index of eighteen pages. The wood-cut illustrations are made by Messrs. J. D. Cooper and M. Lacour, presumably from original designs by the author (though he does not say so) and are in general fair, and in some cases very good, for the purposes of illustration; though they cannot be said to be quite abreast of the best art of illustrated designs, unless some of the representations of crystals and rocks be excepted from this statement. The author, of course, presents a picture of Fingal's Cave (page 219), without which no English text-book of geology would be complete, but he avoids the errors so humorously alluded to in the *Engineering and Mining Journal* last year, by taking his point of view at such a distance that the observer is unable to say whether the "whole back of the cave has been taken out as useless" or not. The advantage that this may have, however, is compensated by a lack of definition of the striking columnar masses.

This lack of definition is strikingly shown on other illustrations, and notably on that of "Schistose Structure," on page 194, which represents a block, which might as well be a piece of agate or variegated marble as that for which it stands.

On the other hand, the group of calcite (Iceland spar) crystals, on page 166, is an admirable piece of wood cutting: but even here the original design, though doubtless quite true to nature, might have been made at such an angle to the visual ray as to avoid the deception of cubical cleavage. The illustration, on page 142, of the "outline of a volcanic neck," has the fault, for a book of this kind, that it is not characteristic, though doubtless Dr. Geikie could tell us just where this phenomenon could be observed. It is nothing but a very ordinary little rounded hill, suggesting in its outline a granite or heavy bedded gneiss nucleus. It is difficult to understand, even in his vertical section, how the line of demarcation between the sedimentary exterior and the volcanic core should be entirely unmarked by any topographical feature. On page 125, we are told that "crust" is used "without implying any theory as to the nature of the interior of the globe;" and, on page 126, one reads that "it is quite certain that the interior of the globe must be intensely hot."

The book is a useful one for beginners in geology, and derives much of its value from the author's lucid and simple English style. P. F.

THE MANUFACTURE, CONSUMPTION AND PRODUCTION OF IRON, STEEL AND COAL IN THE DOMINION OF CANADA, WITH SOME NOTES ON THE MANUFACTURE OF IRON AND ON THE IRON TRADE IN OTHER COUNTRIES. By James Herbert Bartlett. Montreal: Dawson Brothers. 1885.

This is a very interesting and complete as well as convenient table of statistics which is chiefly unfortunate in its unintelligible title. The consumption and production of coal and the manufacture of steel and iron are economical data, which more than any others fix the commercial status of the nation, but what is one to understand. The publisher of the volume, Mr. Dawson (himself an author and a purist), is one of the last persons one would have suspected of printing such a sentence. It must be said, however, that

the manufacture of coal, of crude petroleum, rock salt and the like are terms not unfrequently met with. This defect in the title, however, does not prevent the volume from being one of great statistical value to the economist, and especially to the iron manufacturer.

The patriotic author deplores the condition of the iron industry in Canada, and seeks to prove that she has the ore, she has the coal, and she has the talent too (to alter slightly the popular Jingo song in Disraeli's time). This view has also the merit of being justified by the facts.

The introduction forms the first chapter. The second is devoted to the St. Maurice forges; the third to the early enterprises in Ontario; the fourth to iron smelting in New Brunswick. Chapter V, on the manufacture of iron in Nova Scotia, consists largely of tabular statements of the "domestic production of iron, steel and coal." All this part of the book (except the introduction) has been read as a paper before the Institute of Mining Engineers at its Halifax meeting last fall.

The remaining chapters, VI, VII and VIII, deal respectively with (Chapter VI) iron ores, fluxes and commercial classification; (Chapter VII) improvements in the processes of manufacture, and (Chapter VIII) how other countries have fostered the iron industry. These very broad subjects are very lightly touched upon, except the last. In the conclusion, the writer favors specific and not *ad valorem* duties. He thinks the figures of the Custom House show that Canada has a non-protective tariff, and that she is constantly draining herself of large amounts of money, in order to pay for what she ought to produce within her own borders, and she has not even the consolation of getting iron any cheaper than it can be got in the United States.

The appendix of twelve pages is devoted to a comparative statement of the import duties. F.

THE MATERIALS OF CONSTRUCTION. By Robert H. Thurston, M. A., Doc. Eng. New York: John Wiley & Sons.

This second work by Professor Thurston is an abridgment of his large one. We abstract from the preface the following, which exhibits the scope of the work: The essential parts only of the earlier treatise have been retained. The volume thus constructed is of manageable size, is of such comparatively low cost that it can probably be brought into use in any technical school; and yet it contains enough of the matter collected in the extended work to furnish a basis for the course of instruction and machine design taught in the most elaborate course yet adopted in any such schools. The origin, nature, method of preparation, and the useful properties of all the common and so-called useful metals, and their strength, elasticity and other qualities essential to their introduction into the various constructions, which the engineer is called upon to build or to inspect, are treated of at considerable length, and the influence of the more common conditions affecting them is studied. C. A. E.

TABLES FOR CALCULATING EARTHWORKS. By John R. Hudson, C. E. New York: John Wiley & Sons.

These tables are apparently founded upon the method of Henck given in his pocket-book, of which they endeavor to be a simplication. It is rather difficult to pronounce upon the superiority of any method of calculating earthworks; so much depends upon that to which an engineer has habituated himself. Custom on this point seems to guide the preference of every practitioner. Again, some engineers appear to regard all refinement as inapplicable to the calculation of earthworks; in their opinion the contents are simply a rather rude approximation, necessarily so from the irregularities of the ground being so sudden in many instances. Hence they average the end sections and multiply the result by their distance apart. But some strong arguments may be advanced in support of the opposite course. Hudson's tables may prove of interest and use, and are certainly entitled to as much consideration as any others.

C. A. E.

A TREATISE ON THE MANUFACTURE OF SOAP AND CANDLES, LUBRICANTS AND GLYCERINE. By Wm. Lant Carpenter, B. A., B. Sc. E. & F. N. Spon. 1885.

This treatise is an octavo of some 350 pages, with numerous illustrations, good print and bad binding. The author, as he states in his preface, has been engaged in these industries for several years, and is therefore able to speak upon the practical points of many of the subjects described, as one having authority.

There are a number of tables of specific gravity, freezing points, etc., also the specifications of over 100 patents. Many of these have been issued within late years; some as late even as 1884. This same characteristic of being "up to date," appears throughout the volume, in references to the recent numbers of scientific journals, etc.

The book is exhaustively written, and proper attention is given to the scientific principles involved. Sometimes the elaboration is carried too far; as in the description of Leblanc's process of manufacturing soda ash. If there be a subject in technical chemistry that has been thoroughly studied and written upon, it is this same Leblanc process. And to go over the ground again is only a waste of paper and printer's ink.

The book is divided as follows: Eight chapters are given to the manufacture of soap, one to lubricating oils, three to candles, stearine, etc., and one to glycerine. And, last, but not least, the author closes with a good index.

H. P., JR.

A GUIDE TO SANITARY HOUSE INSPECTION. By William Paul Gerhard, C. E. New York: John Wiley & Sons. 1885.

The principal aim of this work, as stated in the prefaces, is to broadly outline the main features of sanitary house inspection for the guidance of the householder. It is not designed to be a work on sanitary appliances and construction, but as a directory of the points requiring attention. We heartily endorse the following passage. "No prudent man would think of buying a

house without carefully examining the title of the property; and it is now regarded, in real estate transactions, as a necessary expenditure to pay competent lawyers for services rendered in securing evidence as to the correctness of the title of a property before concluding a bargain. But not one out of a hundred or more purchasers would deem it of sufficient importance to secure a certificate from an expert that the house is built in accordance with sanitary rules and regulations. And yet, if the buyer intends to make the house his future residence, his own health, and that of his family and household, will depend upon its cleanliness and salubriousness. The same remarks apply, with equal force, to houses for rent, located in the city, in the suburbs, or in the country."

In speaking of country houses he says: "A public supply delivering water to all habitations in pressure-conduits or street-mains, is seldom available; and drinking water must usually be drawn by buckets or pumps from a well on the premises, sunk to only a shallow depth, and often liable to be contaminated from surface washings, or by careless dipping into it of unclean vessels. Driven wells are not so liable to surface contamination; yet even they may be poisoned by leakage of sewage, unless sunk to a very great depth, and penetrating below some impervious stratum. It sounds like a truism to say that wells supplying drinking water must be most scrupulously watched, and kept free from contamination; yet how seldom is proper care bestowed upon this matter! The drain which carries the liquid wastes from the house to a cesspool often passes near the well; and unless the pipes are laid with unusual care and forethought, by experienced workmen, the imperfect and often uncemented joints and broken pipes allow the slop water to leak into the soil, from which it passes by filtration into the well.

"But the most frequent and most dangerous causes of the contamination of wells are the leaching cesspool (that vast receptacle of decomposing organic matter from the household), and the privy, both generally located, on account of convenience and economy, very near the house."

The work is printed in large type and is well adapted to fulfil its mission; being a creditable addition to this class of literature. W. B. C.

HEALTHY FOUNDATIONS FOR HOUSES, with fifty-one illustrations. By Glenn Brown. New York: D. Van Nostrand.

This is one of the numerous reprints issued by this establishment. The following passage explains the scope of the work: "To obtain healthy foundations, it is necessary to select or so treat the building site that it will be free or protected from vegetable and animal matter in the subsoil, which, in the process of decay, would generate poisonous gases; it must also be free, naturally or artificially, from dampness—*i. e.*, there must be no springs, watercourses or standing water within the area of ground covered by the building.

"It being an accepted fact that damp and polluted soils are unhealthy when used as foundations, it only comes within the province of a treatise of this kind to show how buildings can be protected from the evils which would be produced."

A detailed description of the various methods of constructing and draining foundations is given, with reference to those adopted by the Greeks and Romans.

The work is one which forms a desirable addition to the extensive list of publications of its class. W. B. C.

LIST OF BOOKS.

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New York. Board of Commissioners of Central Park. Fourteenth Annual Report, 1870. New York. [This completes this series. The Board having been abolished and the Department of Public Parks created, the first report of which is dated 1871 (May).—E. H.]

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